INSTRUCTION MANUAL

FOR THE

GLIDE SLOPE SIGNAL GENERATOR
TYPE 232-A

BOONTON RADIO CORPORATION
BOONTON, NEW JERSEY
U. S. A.

1—56

Printed in U. S. A.

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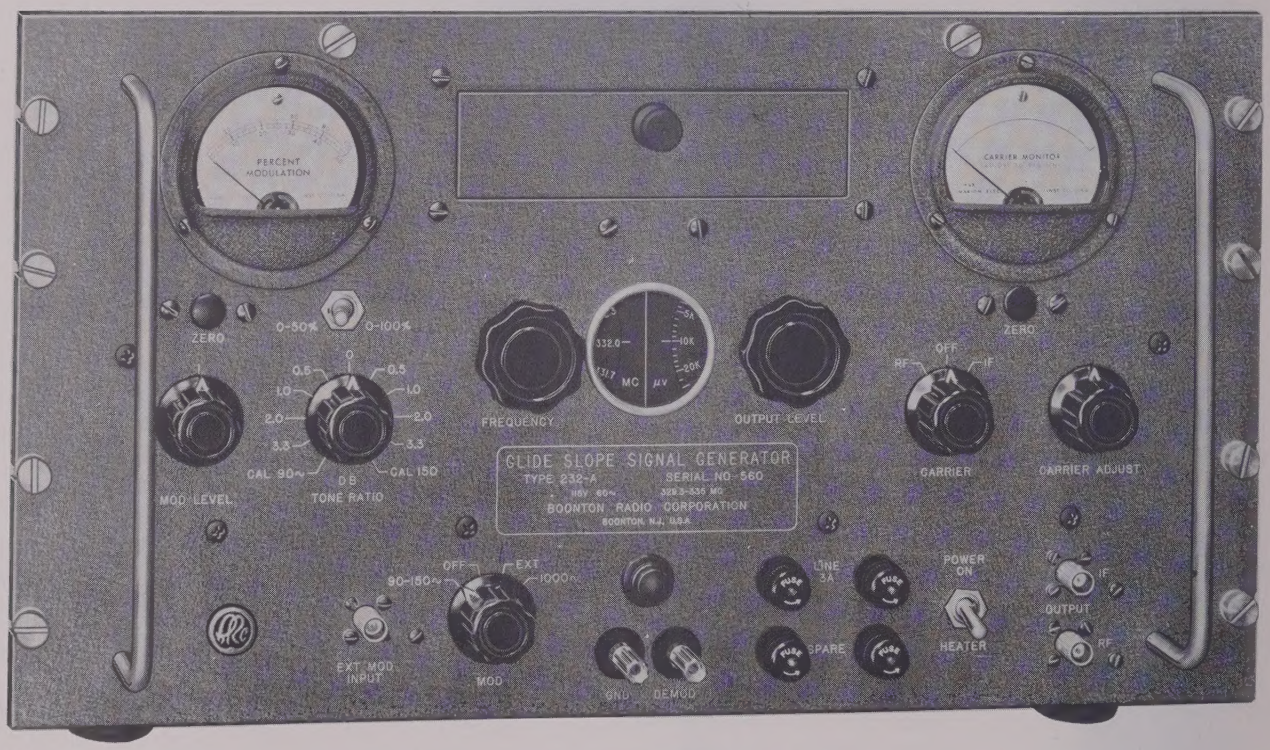


Figure 1. Glide Slope Signal Generator Type 232-A

SECTION I
GENERAL DESCRIPTION

FUNCTION

The Glide Slope Signal Generator Type 232-A is designed primarily to test and calibrate Glide Slope receivers that are part of the aircraft Instrument Landing System commonly known as the "ILS".

The "ILS" consists of three basic elements: marker beacons, localizer and glide slope path signals. These elements, functioning independently, enable an incoming aircraft to locate itself at the threshold of the runway with the correct heading, altitude and airspeed in order to execute a safe landing under low ceiling and visibility conditions. The elements may be briefly described as follows:

1. The marker beacons are low power transmitters which radiate vertically in a cone shaped pattern having a elliptical cross-section. The markers, operating at a frequency of 75 mc, are located along the approach path and serve to indicate the progress of the aircraft toward the runway.

2. The localizer radiates a narrow bi-directional field pattern which establishes the correct final approach and landing course, enabling the landing aircraft to arrive at the threshold of the runway flying directly down the center. Operation is in the vhf range between 108.1 and 111.9 mc.

3. The glide slope path is a narrow sloping pattern which brings the landing aircraft down at the correct descent angle in order to clear all obstructions and arrive at the threshold of the runway at the correct landing altitude. Operation is in the uhf range between 329.3 and 335 mc.

The localizer and glide slope patterns are similar in that for each a single carrier is modulated simultaneously with both 90 and 150 cycle tones. The antenna system of each is such that a 90 cycle tone is radiated to one side of a precisely oriented dividing plane and a 150 cycle tone is radiated to the other side, while in the plane itself (actually a narrow angular sector) equal proportions of both signals exist. The glide slope center plane is 1° wide and slopes up from the runway at an angle of approximately 2½°. The localizer is vertical and oriented along the center line of the runway.

Localizer radiation is in a horizontal plane while the glide slope signal is normally radiated at an oblique angle of 2½° from the threshold of the runway.

The signal element with which the Glide Slope Generator is concerned is the glide slope path. The Generator accomplishes its functions of test and calibration of the Glide Slope receiver by reproducing the signal that exists along the glide path, thus simulating operational conditions. Accordingly, the instrument provides 20 crystal controlled rf frequencies between 329.3 mc and 335 mc in 0.3 mc incremental steps and an i-f signal generated by a crystal controlled circuit designed to operate at any desired point between 15 and 30 mc with the appropriate crystal.* Both rf and i-f signals can be modulated with a dual signal of 90 and 150 cycles. "Above Course", "On Course", and "Below Course", signals are simulated by varying the ratio of modulation of these tones to each other through a differential attentuator (DB Tone Ratio Control).

DESIGN

The instrument is contained in a single cabinet and consists of the following electronic units: (See Figure 10).

Unit	Location
RF Generator	Front Left
IF Generator	Front Left
Modulation Amplifier	Rear Center
1000 Cycle Oscillator	Front Right
Metering Circuits	Front Right
Tone Generator Circuits	Rear Center
Power Supply	Rear Right

The above units comprise a chassis that is easily removable from its aluminum frame. Rigid handles are mounted on the front panel for carrying the instrument.

The rf, i-f sub-assembly is completely shielded and accessible by the removal of the screws holding the top and bottom covers. The dual alternator can be removed by simply taking out the four mounting bolts that hold it.

ACCESSORIES SUPPLIED

1. 6 db attenuator adapter — 50 to 50 ohms unbalanced, BNC to BRC Type 505-B.
2. 6 db attenuator adapter — 50 ohms unbalanced to 05 ohms balanced. BNC to small twin uhf — BRC Type 507-B.
3. I-F Output Cable — 50 ohm internal terminations, clip leads — BRC Type 514-B.
4. Patch Cable — BNC to BNC — 6 feet. BRC Type 506-B.

SPECIFICATIONS

(Unless otherwise noted, specifications apply to both rf and i-f output).

Frequency Range:

RF — 329.3 to 335 mc in .3 mc increments (20 channels).

**The instrument is furnished with an i-f frequency crystal of 20.7 mc.*

I-F — 20.7 mc (can be changed to any frequency between 15 and 30 mc by changing crystal and retuning i-f circuits).

Frequency Accuracy:
±0.0065% from −40° to +55° C. ambient temperature.

Output Level:
1 to 200,000 μv ±10%.

Generator Internal Impedance:
50 ohms.

Output Monitor:
Set-to-line type panel meter.

Modulation:
0 to 100%, continuously variable and indicated on calibrated panel meter. Modulation by internal 90 and 150 cycle or 1000 cycle sources, or by an external source (1.5v into 50,000 ohms). The 90 and 150 cycle modulation tones are available either separately or combined in the ratio of 0 db, ±0.5 db, ±1.0 db, ±2.0 db or ±3.3 db.

Overall Modulation Distortion:
Less than 2% at 40% modulation and less than 5% at 90% modulation, measured at the *Demod.* binding posts when using either 90 or 150 cycle internal modulation.

Power Source:
105 - 125v, 60 (±1) cycle only.
Power Consumption — 140 watts.

Tubes and Indicator Lamps:

4 — 6AU6	V1, 3, 9, 15
1 — 6005/6AQ5	V2
3 — 12AT7	V4, 8, 11
2 — 538-B (Selected 12AT7s)	V5, V10
1 — RCA6173	V6
1 — 5726/6AL5W	V7
2 — 546-A (Selected 6X4Ws)	V12, 13
1 — 6AS7G	V14
1 — OB2	V16
1 — 16-4	RT2
1 — 47	I1
1 — 3S6/5	RT1

Dimensions:
Panel — Standard 19″ relay rack panel, 19″ wide x 10½″ high.

Depth of chassis behind rear of panel — 13 9/16″ (exclusive of power cord).

Overall Dimensions in Cabinet — Height, 11⅜″; Depth, 16-3/16″; Width, 20⅞″.

Weight:
64 lbs.

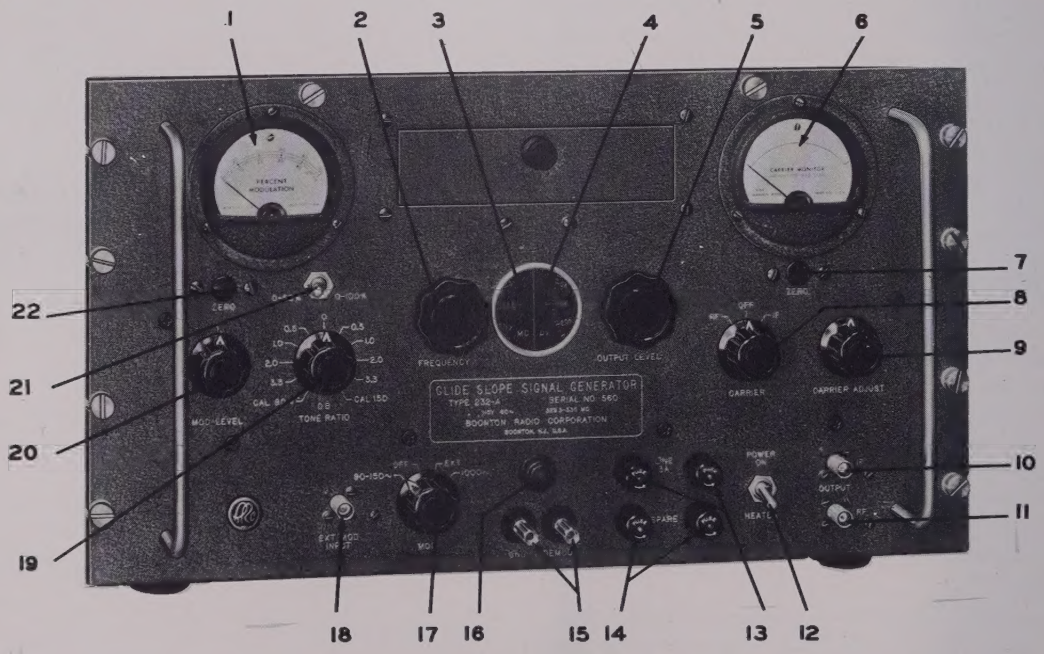


Figure 1a. Front Panel Control Layout

1	Percent Modulation Meter	8	Carrier	13	Line Fuses (3a)	18	Ext Mod Input
2, 3	Frequency Knob and Dial	9	Carrier Adjust	14	Spare Fuses	19	DB Tone Ratio
4, 5	Output Level Knob and μv Dial	10	Output IF	15	Gnd Demod	20	Mod Level
6	Carrier Monitor Meter	11	Output RF	16	Pilot Light	21	0-50% 0-100%
7	Zero	12	Power	17	Mod	22	Zero

SECTION II
OPERATION

PREPARATION FOR USE

The Glide Slope signal generator is supplied in a cabinet but may be rack mounted if desired after removing it from the cabinet.

Connect the output of the generator to the receiver to be checked. For rf measurements, use the 6 foot Patch Cable Type 506-A and the appropriate Attenuator-Adapter Type 505-A or Type 507-A. For i-f alignment use the i-f Output Cable Type 514-A.

Connect the power cord to a 105-125v 60 cps source only.

PANEL LAYOUT AND CONTROLS

See Figure 1a

Name	Function
1 Percent Modulation Meter	Indicates percent modulation when *Carrier Monitor* meter is set to the red line. Used for both rf and i-f generators.
2,3 Frequency Knob and Dial	Selects and indicates the carrier frequency when the *Carrier switch* is in the *rf* position.
4,5 Output Level Knob and μv Dial	This control sets the output in μv of both i-f and rf generators when the *Carrier Monitor* is set to the red line.
6 Carrier Monitor Meter	Attenuator is calibrated when the meter is adjusted to the red line. Serves for both rf and i-f generators.
7 Zero	Used to set *Carrier Monitor* meter to zero when *Carrier switch* is in the *Off* position.
8 Carrier	Carrier selector switch. Three positions: *RF* — RF generator on. *Off* — Both i-f and rf generators off. *IF* — IF generator on.
9 Carrier Adjust	Used to adjust the *Carrier Monitor* meter to the red calibration line.
10 Output IF	The i-f output signal is obtained from this connector.
11 Output RF	The rf output signal is obtained from this connector.
12 Power	Switch that applies power to circuits in *On* position and power to standby heater in *Heater* position.
13 Line	Fuse posts which hold the operating fuses.
14 Spare	Fuse posts for the spare fuses.
15 Gnd Demod	The *Demod* binding post is connected through a 2 μf blocking capacitor to the demodulated carrier signal.
16 Pilot Light	The red light indicates the standby heater is off and the circuits are energized.
17 Mod	Modulation selector switch. Selects modulation signal applied to the input of the modulation amplifier. This switch has 4 positions: *Off* — No modulation applied to the carrier. *Ext* — Permits modulation of the carrier by an audio signal applied to the *Ext Mod Input* connector. *1000*~ — Provides modulation of the carrier by the internal 1000 cycle oscillator.
18 Ext Mod Input	Connector to which the external modulation signal is applied.
19 DB Tone Ratio	This switch is used to select the required relative amounts of 90-150 cycle tone signal. It has eleven positions, five of which vary the ratio of modulation in favor of the 90 cycle signal and five that vary the ratio in favor of the 150 cycle signal. The 0 db position indicates equal amplitudes of the two tone signals. Clockwise rotation increases the predominance of the 150 cycle signal. Counterclockwise rotation increases the predominance of the 90 cycle signal.

Name	Function
20 *Mod Level*	Permits adjustment of percent modulation from 0 to 100%.
21 0-50% 0-100%	Range switch for Percent Modulation meter.
22 Zero	Meter adjustment screw. Used to set *Percent Modulation* meter to zero when the *Mod* selector switch is in the *Off* position.

The following controls are located behind the small door on the front panel (See figure 10):

Modulator Output	The output of the modulation amplifier is coupled thru a transformer to this connector.
90~	This control is used to set the level of the 90 tone signal.
150~	This control is used to set the level of the 150 tone signal.
1000~	This control is used as an auxiliary level set for the 1000~ modulation signal.
Meter Calib.	These tip jacks give access to the dc voltage across the *Carrier Monitor* meter for the purpose of checking this meter.

PRELIMINARY PROCEDURE

With the *Mod switch* on *Off* and the *Carrier* switch on *Off,* throw the *Power* switch to *Power On.* Allow the instrument to warm up for five minutes.

If the *Carrier Monitor* and the *Percent Modulation* meters do not indicate zero, remove the plug button near the meters and adjust the *Zero* controls for zero meter reading.

With the Carrier switch in the *RF* position, rotate the *Frequency* turret through all twenty crystal positions and see that the *Carrier Monitor* meter can be set to the red line at each frequency with the *Carrier Adjust* control.

With the *Carrier* switch at *RF,* select any frequency and adjust the *Carrier Monitor* meter to the red line using the *Carrier Adjust* control.

Throw the *Mod* switch to 90-150~,*DB Tone Ratio* switch to *Cal 90~* , *Modulation Meter* range to *0-100%.* See that the *Percent Modulation* meter can be set to 40% using the *Mod Level* control.

Set the *DB Tone Ratio* switch to *Cal 150~.* See that the *Percent Modulation* meter can be set to 40% using the *Mod Level* control.

Turn the *Mod* switch to 1000~. See that the *Percent Modulation* meter can be set to 100% using the *Mod Level* control.

CW OPERATION

RF Generator:

1. Set *Carrier* switch on *Off.* Check and if necessary adjust the *Zero.*

2. Set the *Mod* switch on *Off.*

3. Set the *Carrier* switch on *RF.*

4. Set the *Frequency* selector to the desired frequency.

5. Adjust the *Carrier Monitor* meter to the red line using the *Carrier Adjust* control.

6. *Set the μV Dial* to the desired rf output level using the *Output Level* knob. The rf signal can now be obtained from the *RF Output* jack.

IF Generator:

1. Set *carrier* switch on *IF.*

2. Adjust the *Carrier Monitor* meter to red line using the *Carrier Adjust* control.

3. Set the *μV Dial* to the desired i-f output level using the *Output Level* knob. The i-f signal can now be obtained from the *IF Output* jack.

MODULATION: 90-150~

The standard glide slope signal is defined as a modulation of combined 90-150 cycles with 40% modulation of 90 cycles and 40% modulation of 150 cycles applied simultaneously for the "On Course" condition.

To obtain this signal, set the *Carrier* switch to *RF* and the *Frequency* turret control to the required frequency and adjust the *Carrier Monitor* meter to the red line using the *Carrier Adjust* control. Set the *Mod* switch to *90-150~* and the *DB Tone Ratio* switch to *Cal 90~* . Set *Percent Modulation* meter to 40% using the control marked *90* behind the small door on the front panel. Switch *DB Tone Ratio* switch to *Cal 150~*. Do not disturb the *Mod Level* control. Set *Percent Modulation* meter to 40% using the control marked *150* behind the small door on the front panel. Switch from *Cal. 90~ to Cal 150~* several times to be sure they are equal.

Throw the *Percent Modulation Range* switch to *0-100%* and set the *DB Tone* Ratio switch to *0 DB.* This is the standard glide slope signal described above. The *Percent Modulation* meter will indicate the total percent modulation. Note this reading.

The *DB Tone Ratio* switch can now be used to simulate the "Off Course" conditions each side of center.

If the *Carrier* frequency is changed, set the *Carrier Monitor* meter to the red line, then reset *Percent Modulation* meter to the figure noted previously with the *DB Tone Ratio* switch on *0 DB* position. Alternatively, the modulation can be reset by checking the 90-150~ modulation at the 40% level as above.

MODULATION: 1000~

Select the desired carrier frequency and set Mod switch to 1000~.

Set the *Mod Level* control at mid-rotation and set the *1000* cycle control behind the door to 40% modulation as indicated on the *Percent Modulation* meter. Any desired percent modulation can now be selected by means of the *Mod Level* control.

EXTERNAL MODULATION

Select the desired carrier frequency. Set *Mod* switch to *Ext.* Using an external audio source, apply the modulation signal to the *Ext Mod Input* jack. The requirement for 100% modulation is approximately one volt. The percent modulation can be varied by the *Mod Level* control.

SECTION III
THEORY OF OPERATION

BLOCK DIAGRAM

Figure 2 shows the functional block diagram of the Glide Slope Generator Type 232-A. It consists of six electronic units plus a power supply in a single case—

RF Generator
IF Generator
Modulation Amplifier
1000 Cycle Oscillator
Metering Circuits
Tone Generator Circuits

RF, IF Generators

Separate crystal controlled oscillators are used to generate the rf and i-f signals. Each oscillator is followed by the necessary multiplier stage (or stages) to produce the specified output frequency. Each section has its own demodulator, but a single cathode follower is switched to serve as an impedance transformer for the section in use.

Two piston type attenuators, having a common drive system and dial calibration, but otherwise functioning as independent units, couple the rf and i-f outputs to the panel receptacles.

Standardized rf and i-f output is obtained by holding the output voltage across each of the final tank circuits at a fixed level. This is monitored by the *Carrier Monitor* meter, which reads the rise in demodulator output voltage due to the carrier and which is always set to read at its red line.

Modulation

Modulation of the rf carrier is accomplished by simultaneously plate modulating both the output doubler and the preceding doubler stages. Both the ac modulating voltage and the necessary dc plate voltage for the two stages are obtained from a circuit connected to the plate of the second modulator amplifier. The percent modulation is held esentially constant over a wide range of settings of the *Carrier Adjust* control, thus reducing the need for resetting the *Mod-Level* control to maintain the required modulation percentage.

Modulation of the i-f carrier is produced by both screen and plate control of the pentode output stage, but is otherwise similar to the r-f modulation.

Percent modulation is indicated by an *average reading* type of ac vacuum tube voltmeter which reads the ac component of the demodulated carrier. This is calibrated to read directly in percent modulation (when the *Carrier Monitor* meter has been set to the red line).

90 and 150 cycle tone modulation is provided by a system consisting of a dual alternator driven by a synchronous motor, a harmonic filter with separate sections for each of the tones, and a precision resistive mixing network. Switch positions are provided for independent adjustment of the level of each of the tones, and accurate ratio steps of 0 db 0.5 db, 2.0 db, and 3.3 db, with either tone predominant, are provided.

The carriers can also be modulated by the 1000 cycle tone from the integral RC oscillator or by an external source.

The modulation amplifier provides sufficient amplification and power output to allow 100% modulation of the carrier by the self contained sources or from an external source of at least 1.5 v.

DETAILED OPERATION

In the following sections the order of discussion follows the order of the functions of an elementary signal generator to which are added the various special circuit features required for operational simulation of the Glide Slope signal.

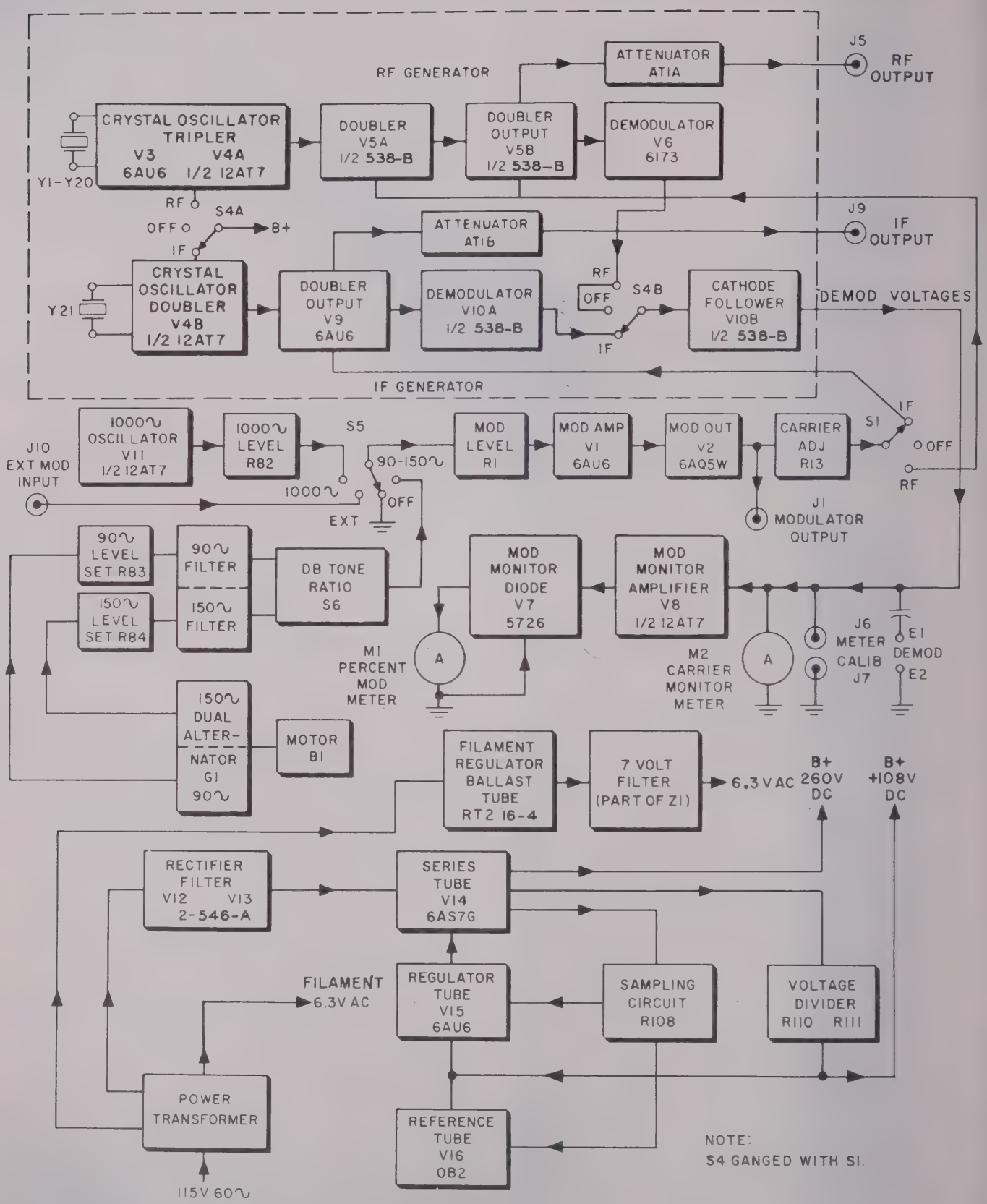


Figure 2. Glide Slope Signal Generator Type 232-A, Block Diagram

RF Generator

The rf generator consists of a crystal oscillator, driver doubler, output doubler and an attenuator.

Plate voltage is applied to the rf generator only when the *Carrier* switch is in the *RF* position.

Anyone of 20 crystals can be selected through the turret switch S2 for operation in a mode type "Butler Oscillator" circuit. V4A and V3 are mutually coupled by the crystal selected between their cathodes. Choke L-27 and blocking condenser C-63 are used to parallel resonate the cathode to cathode capacitance including the crystal shunt capacitance. The plate tank inductor L13 (plate of V13) is tuned to the approximate center of the frequency range (27.441 mc to 27.916 mc). Oscillations are sustained by feedback from the plate of V3 to the grid of V4A, which operates in Class C and develops a bias across grid resistors R22 and R23. Cathode resistors R-19 and R-20 provide sufficient bias to protect the tubes in case of failure or removal of the crystals. The plate load of the "cathode follower" section V4A is tuned to 81 mc providing frequency tripling. Tuning of this tank has negligible effect on the frequency.

The oscillator is coupled to the driver doubler V5A, a triode operating in Class C, by the overcoupled transformer L-14, L-15. This doubler circuit permits operation of the oscillator at a lower frequency as well as isolating the oscillator from the output stage. Frequency modulation of the oscillator is thereby prevented when modulation is applied to the r-f driver doubler plate circuit and to the r-f doubler output plate circuit. (In order to reduce the distortion during modulation it was found necessary to modulate both the driver and final stages. At 100% modulation the driver is modulated to a depth of about 58%).

The driver V5A is coupled to the output stage V5B, operating Class C, by the overcoupled transformer L16 (V5A plate tank) and L17 (input tank of V5B). Capacitor C-30 is in series with the tube input capacitance and thus reduces the tuning capacitance and permits a larger inductor to be used. Modulating voltages are injected through R-16 and R-26 and an r-f filter into the plate circuit of V5A and into the plate tank of V5B through R29 and an rf filter. Resistors R-16 and R-26 protect tube V5B from overload when the crystal is removed.

A balanced tank is used in the output doubler to permit neutralization of the triode tube. The capaci-

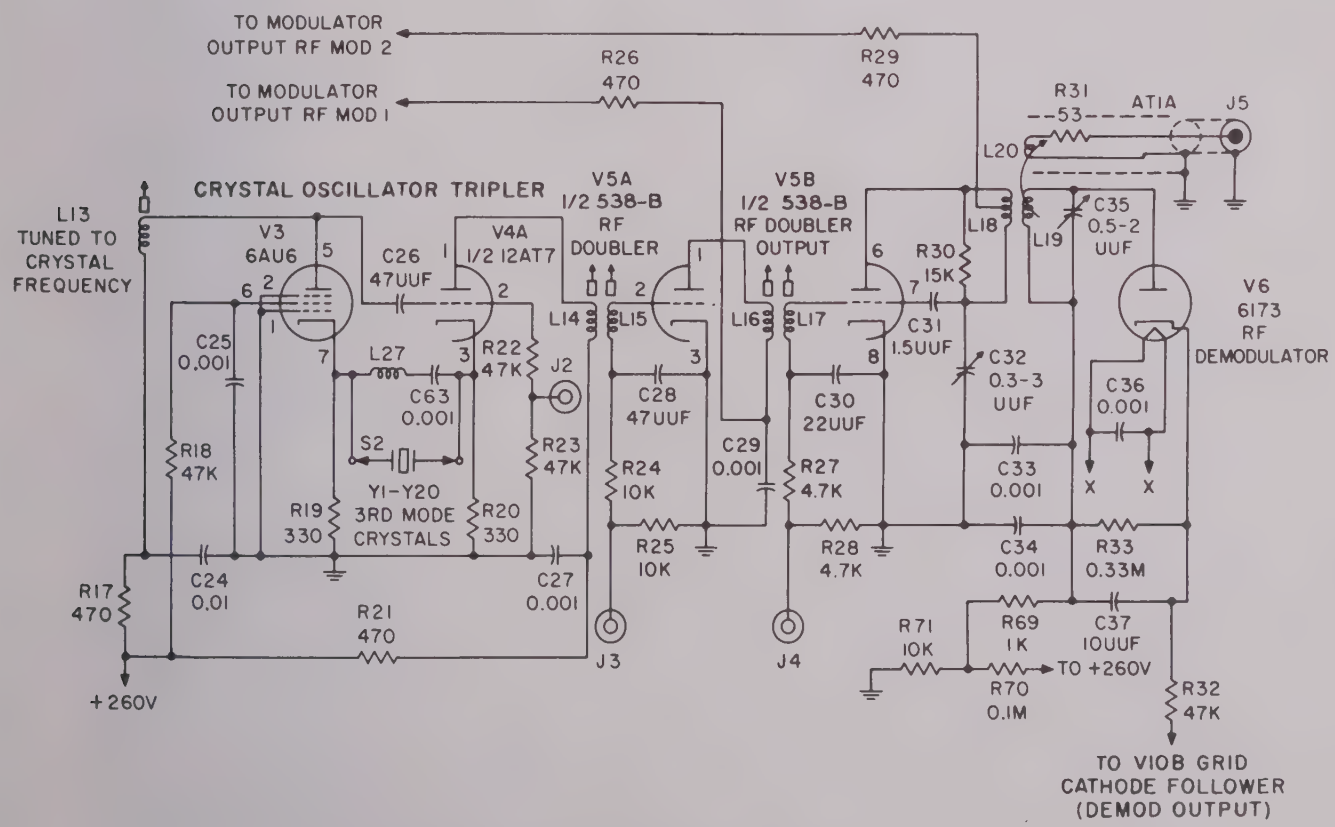


Figure 3. RF Generator, Simplified Schematic Diagram

tance of the tube plate to ground and of capacitor C-32 to ground determine the ground point of inductor L-18. The capacitances should be nearly equal thus placing the center point of the inductor at rf ground potential. C-31 serves to neutralize the stage. Since the output stage is a frequency doubler, exact neutralization is not required. In some cases it may be necessary to readjust L-18 and C-32 in order to get sufficiently good neutralization.

The output of the r-f doubler output stage is coupled by L-19 to the input of a type RCA-6173 pencil diode. The monitoring diode is used to demodulate the modulated or unmodulated rf generator output and this demodulated signal is fed through the cathode follower V10B (Figure 3), to the monitoring circuits. A type RCA - 6173 is used as the rf demodulator because of its low inter-electrode capacitance and low transit time error.

The output of the rf doubler is also coupled by indutor L-19 to a piston type attenuator (AT1A). To provide continuously variable attenuation, the pick-up loop of the attenuator is movable along the axis of the attenuator tube by means of a rack and pinion drive.

IF GENERATOR

Plate voltage is applied to the i-f generator only when the *Carrier* switch is in the *IF* position.

The i-f generator consists of a crystal oscillator, output doubler and output attenuator.

This generator provides output at any frequency in the 15-30 mc range by inserting the proper crystal and tuning capacitors C-45 and C-49 to the proper frequencies.

CR-18/μ crystals with fundamentals at ¼ the desired output frequency are used in the familiar Colpitts circuit using tube V4B. R-59 protects the tube in case of crystal failure and also serves to limit the ampliture of oscillation and thus reduce heating of the crystal. The plate tank is tuned to twice the crystal frequency. Resistor R-15 broadens the response and reduces the drive on the final stage (V9) to the point where it will modulate well.

Capacitors C-45 and C-49 carry approximate calibrations at the output frequency to prevent tuning to the wrong harmonic of the crystal frequency.

The output doubler utilizes a type 6AU6 tube (V9). The circuit is conventional. Shunt feed is employed. Modulation from the modulation amplifier output (see Figure 4) is applied to the screen grid and plate of V9 through resistor R-63 and an rf filter.

The tank voltage of the output doubler is monitored by a diode voltmeter (V10A). A piston attenuator (AT1B) is also coupled to the output tank.

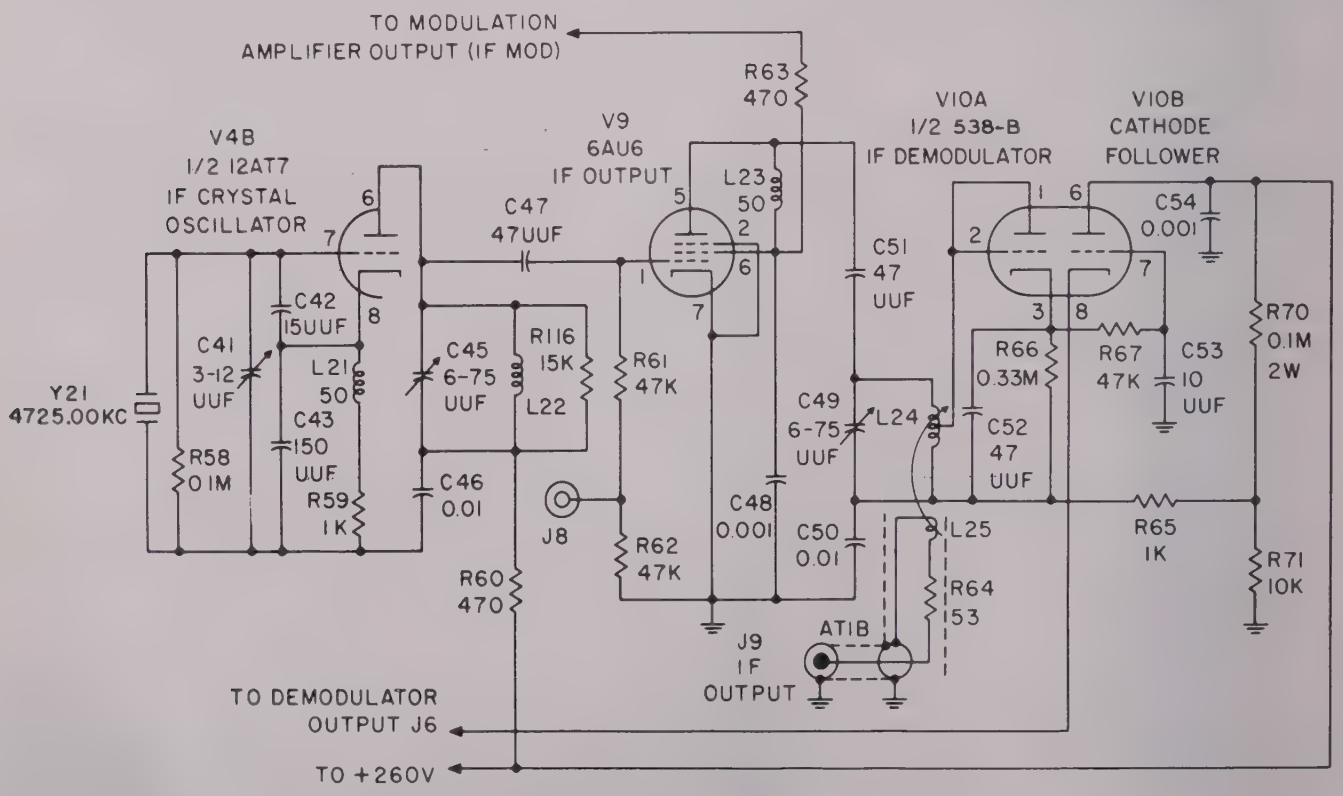


Figure 4. IF Generator, Simplified Schematic Diagram

Metering Circuits

The basic principle of the metering circuitry is the use of a diode demodulator. The dc output of the demodulator is used to monitor the rf carrier level while the ac output is a measure of the percent modulation.

Diode V6 is the rf demodulator. Diode connected triode V10A is the i-f demodulator. V10B is a cathode follower used a low impedance source to pass the demodulator output signal through the rf filter to the metering circuits.

The *Carrier Monitor* meter measures the dc voltage rise in the cathode follower output caused by the application of rf to either of the demodulators. A measured rise of 22 volts has been established as standard for both rf and i-f and is made to produce a "red line" indication on the *Carrier Monitor* meter. Resistors R55, R56, R57 and voltage regulator V16 provide a zero bucking voltage for the Carrier Monitor. R54 is the calibration control.

The ac component of the standardized demodulator output rise is used to measure the depth of modulation. The *Percent Modulation* meter is designed to respond to the average value of the modulation and is relatively insensitive to distortion. Tubes V7 and V8 constitute an average reading voltmeter which measures the percent modulation. R40 controls the feedback level and is used to calibrate the 0-50 percent meter range. R51 is used to calibrate the 0-100 percent modulation range.

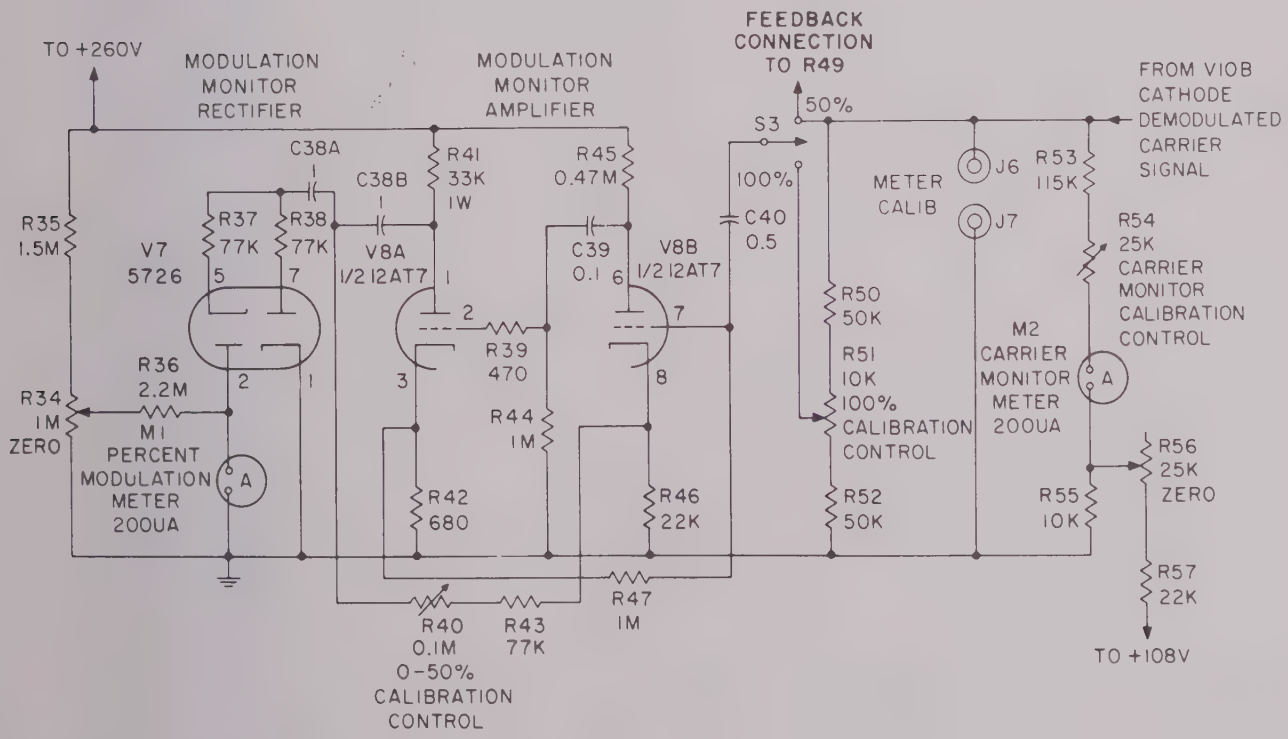


Figure 5. Metering Circuits, Simplified Schematic Diagram

Tone Generator Circuits

The function of the 90/150 cycle tone generator circuit is to simulate the standard glide slope signal. This is defined as a modulation of combined 90 and 150 cycle signals with 40% modulation of 90 cycles and 40% modulation of 150 cycles applied simultaneously for the "on course" condition. "Off course" condition is defined as a predominance of one tone signal over the other. The predominance of the 90 cycle tone signal indicates an "above course" condition, and predominance of the 150 cycle tone signal indicates a "below course" condition.

The 90/150 cycle modulation tones are generated by an internal alternator driven by a 60 cycle synchronous motor (MG1). The modulation ratio of the tone signals to each other is varied by the *DB Tone Ratio selector switch S6*, which is calibrated in terms of the ratio of the tone signal amplitudes expressed in db. These vary from 0 db for the "on course" condition to a maximum of 3.3 db for "above course" or "below course". There are two infinite db positions for calibration of the 90 and 150 cycle tone signals. In *Cal 90* ~ position the 150 cycle tone is shorted to ground and R83 is used to calibrate the 90 cycle tone. With *S6* in *Cal 150* ~ position the 90 cycle tone is shorted to ground and R84 is used to calibrate the 150 cycle tone signal. After passing through the filter Z2, the tone signals are accurately mixed in a precision resistive network before being applied to the input of the modulation amplifier (see Figure 6).

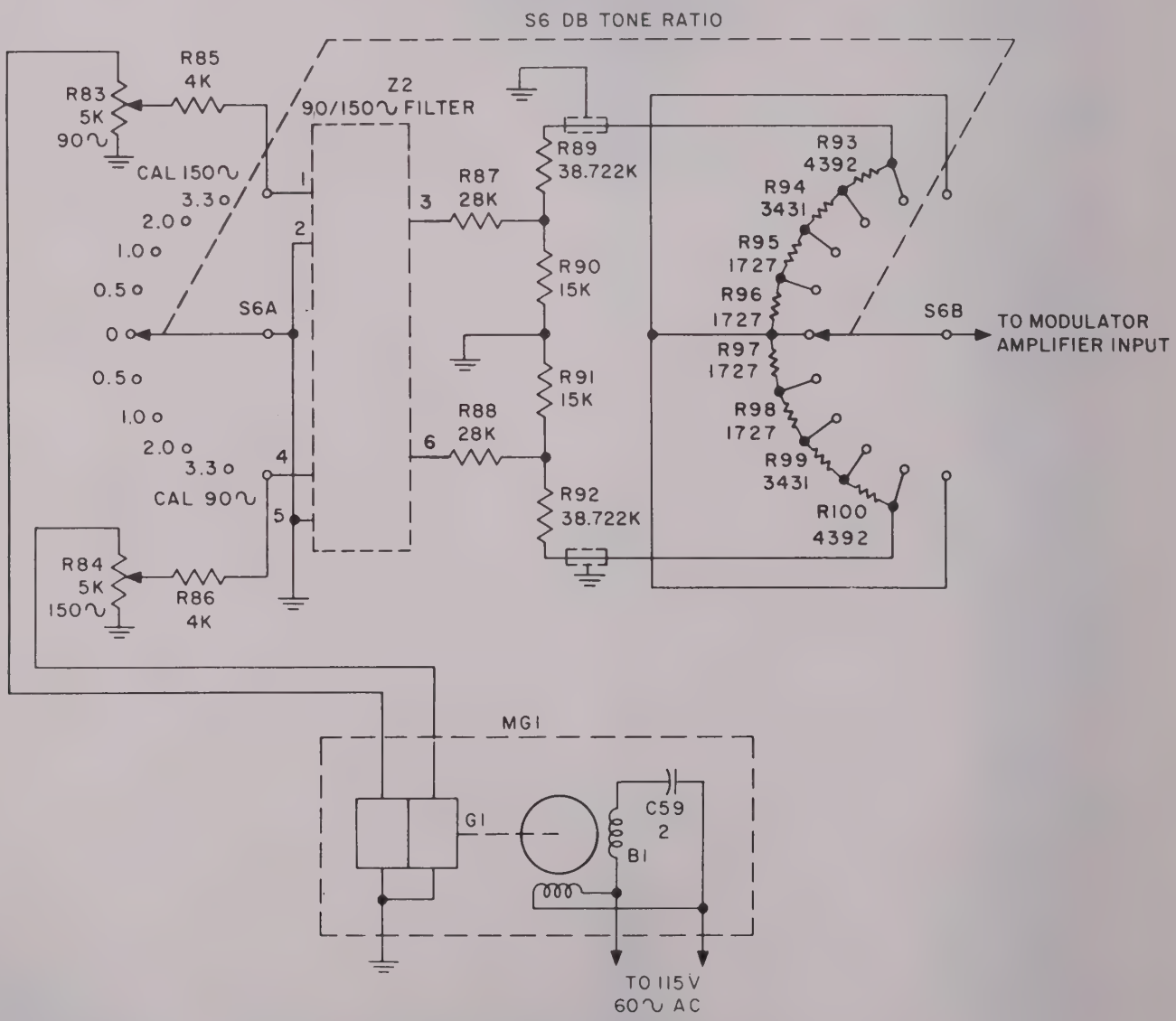


Figure 6. 90/150 Cycle Generator, Simplified Schematic Diagram

The peak modulation depth produced by the mixed 90/150 cycle tone signals varies with phasing. The alternator outputs are phased to simulate the normal condition of minimum peak modulation depth. Analysis shows that the required phasing is such that the closest approach of the peaks of the two signals is 1/900 second, corresponding to a 12° separation angle as referred to a 30 cycle signal.

1000 Cycle Generator

The 1000 cycle tone signal is generated by a Wien bridge-type oscillator having a low harmonic content.

The *Mod* selector switch on the front panel permits selection of either the internally generated signals or, in its *Ext Mod Input* position, connects the input of the modulating amplifier to the *Ext Mod Input* connector located at the bottom of the front panel.

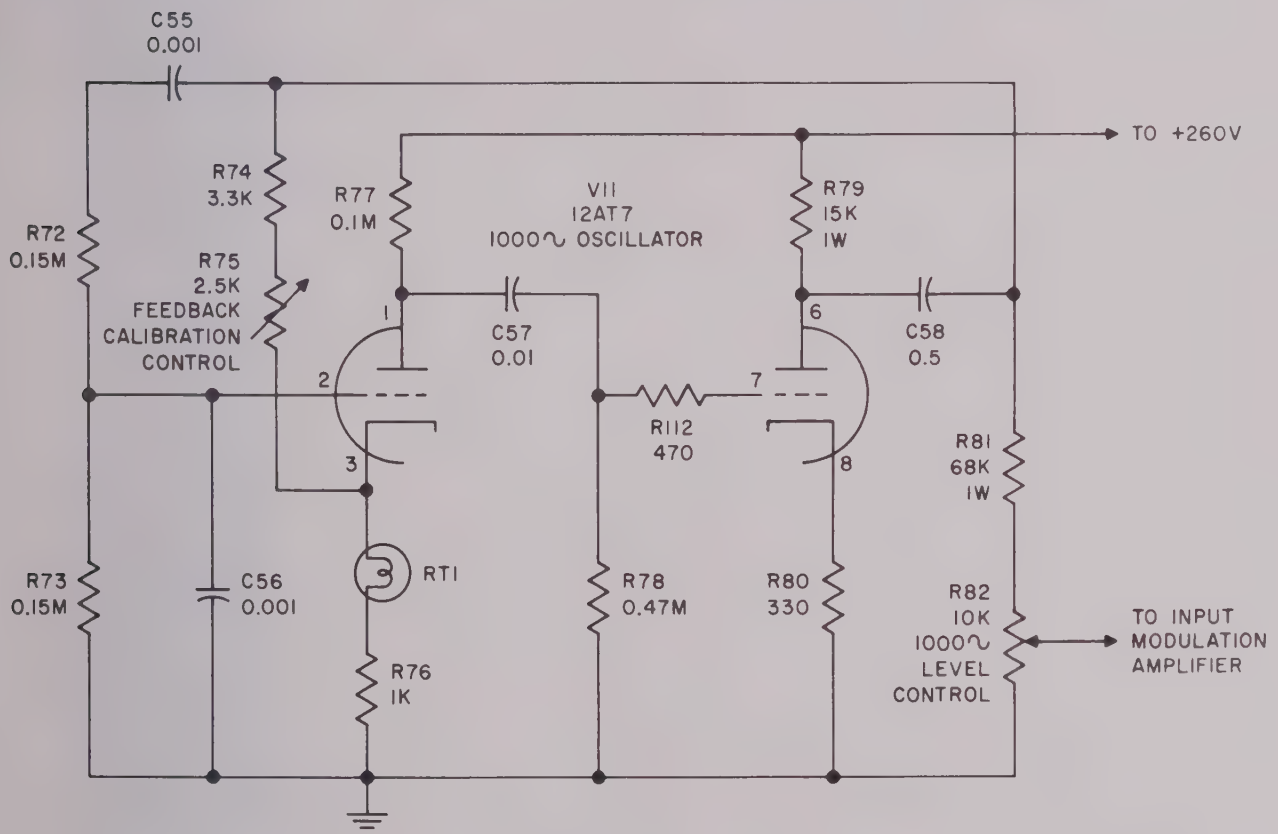


Figure 7. 1000 Cycle Generator, Simplified Schematic Diagram

Modulation Amplifier

The modulation amplifier utilizes tubes V1 and V2. The grid of the first stage is biased up slightly by resistors R2 and R4 in order to increase its gain. The cathode is degenerative and feedback voltage is applied to it. This stage is coupled in a conventional manner to the output stage.

The cathode of the output stage is likewise degenerative. The plate is shunt fed by choke T1. A second winding is applied to this choke in order to supply a low impedance output voltage at *Modulation Output Connector J1.*

Feedback is applied over the amplifier itself by resistors R-10 and R-6. Overall feedback from the input of cathode follower V10B is also applied through R49 and R6 to the cathode circuit of V1. This reduces the distortion present on the carrier modulation by correcting for its non-linearities. In the *Off* position of the *Carrier* switch both rf generators are off so that there is no overall feedback. In order to maintain the gain at approximately the same level, additional feedback is provided across the amplifier by means of R-48.

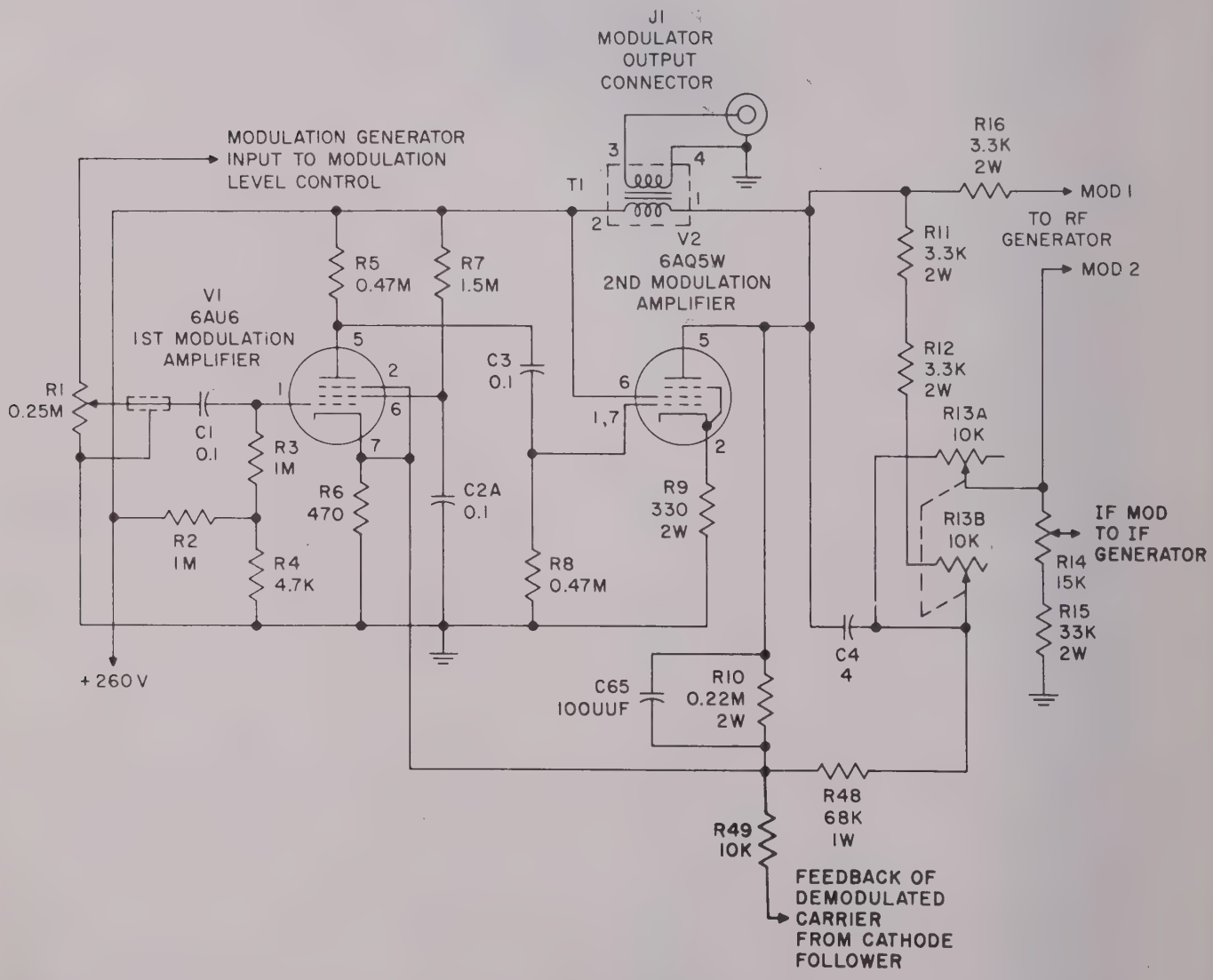


Figure 8. Modulation Amplifier, Simplified Schematic Diagram

Power Supply

The power supply is electronically regulated and provides the power for all units in the instrument. The output voltage is maintained at approximately 260 volts dc when the line voltage varies ±10% of nominal. Both the plate supply and filament supply for the rf and i-f generators are regulated.

A special feature is the use of a space heater resistor (HR1) which is connected across the power line when the *Power-On-Heater* switch is in the *Heater* position. The heat generated by this resistor protects the signal generator against undesired humidity when the equipment is not in use. Another precautionary measure is the wiring of the 260v direct current line through a jumper in the base of the ballast tube RT2. Removal of the ballast tube will disconnect the 260v line from the signal circuits of the generator.

The instrument is available for use on the following power line sources only:

105 - 125v, 60 (±1) cps only. Operation at other than 60 cps (±1) will not be satisfactory since the output frequency of the 90 and 150 cycle tone generator varies directly with the driving speed of the 60 cps synchronous motor.

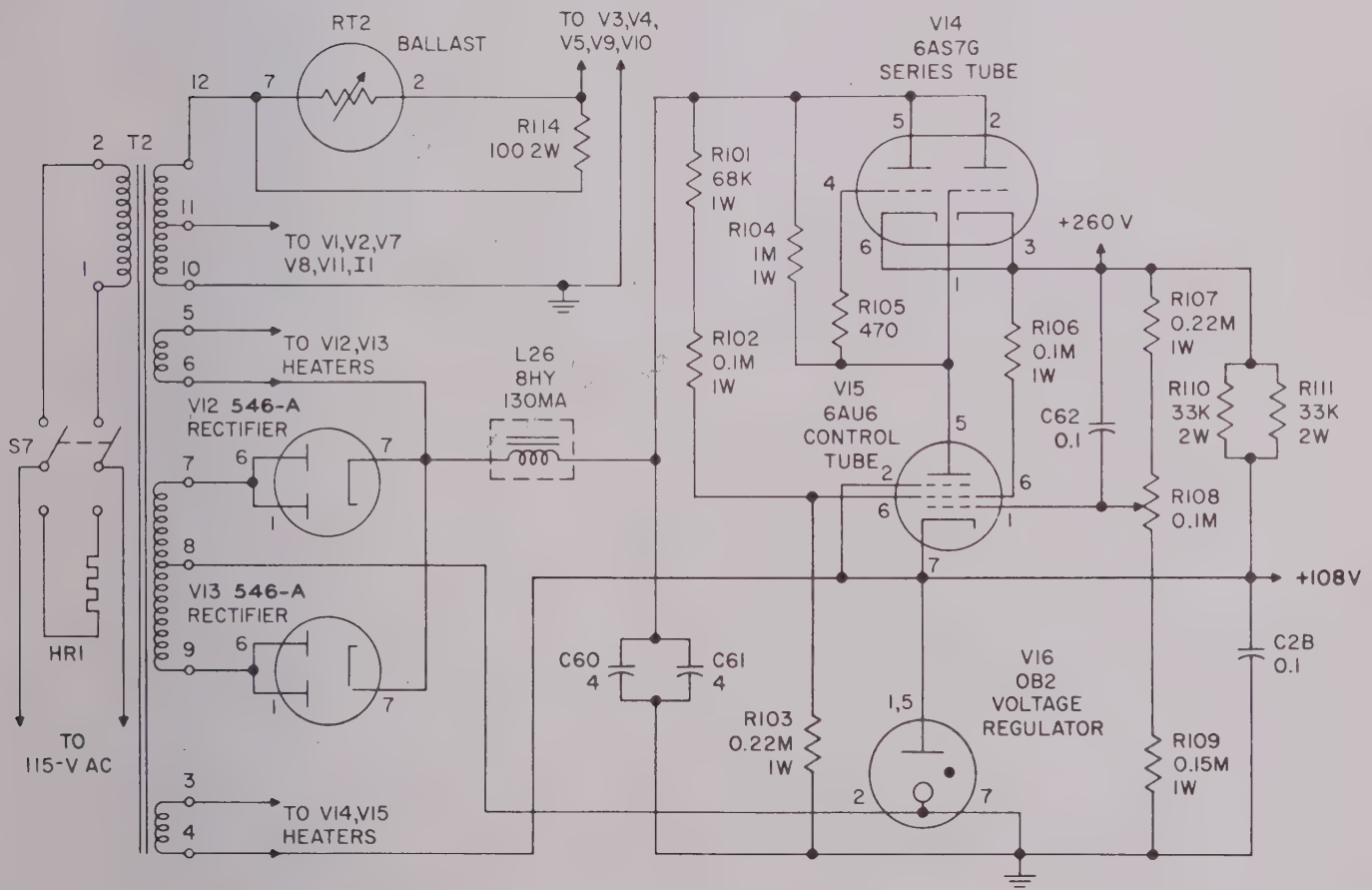


Figure 9. Regulated Power Supply, Simplified Schematic Diagram

SECTION IV
MAINTENANCE AND CALIBRATION

A. GENERAL

The Generator has been carefully calibrated and aligned before shipment and in normal operation no service should be required until tubes have aged beyond their useful life point.

If removed for testing, tubes should always be restored to their original socket position, since tube replacement in certain circuit positions may necessitate re-adjustments or re-calibration.

Normally only the circuits directly affected by a tube change need be re-aligned or adjusted to restore specification performance. Table IV 1 lists, by schematic symbols, all tubes used in the Generator, and indicates the control requiring adjustment.

Symbol	*Type*	*Circuit Function*	*Tube Replacement may require setting of:*	*Refer To (Section):*
V1	6AU6	1st Modulation Amplifier	—	
V2	6005/2AQ5W	2nd Modulation Amplifier	—	
V3	6AU6	RF Oscillator	L13	IV B RF-1
V4	12AT7	RF Oscillator; IF Oscillator-doubler	L13, L14	IV B RF-1, RF-2; IV C IF-1 IF-3
V5	538-B	RF Buffer-doubler; RF Output-doubler	L15, L16, C32	IV B RF-3 through RF-9 inclusive
V6	RCA6173	RF Demodulator	C35	IV B RF-5 through RF-9 inclusive
V7	5726/6AL5W	Modulation Monitor Rectifier	R34, R40	IV F 3
V8	12AT7	Modulation Monitor Amplifier	R40	IV F 3
V9	6AU6	IF Output-doubler	C49	IV C IF-2, IF-3
V10	538-B	IF Demodulator; RF/IF Cathode follower	C49, R56	IV F 2
V11	12AT7	1000~Oscillator	R75	IV D
V12	546-A	High Voltage Rectifier	—	
V13	546-A	High Voltage Rectifier	—	
V14	6AS7G	High Voltage Series regulator	—	
V15	6AU6	Regulator Amplifier	R108	IV E
V16	OB2	Voltage reference	R108	IV E
RT1	3W 115V	1000~Oscillator R75 Stabilization	R75	IV D
RT2	16-4	RF/IF Heater Regulator (ballast)	—	

TABLE IV—I

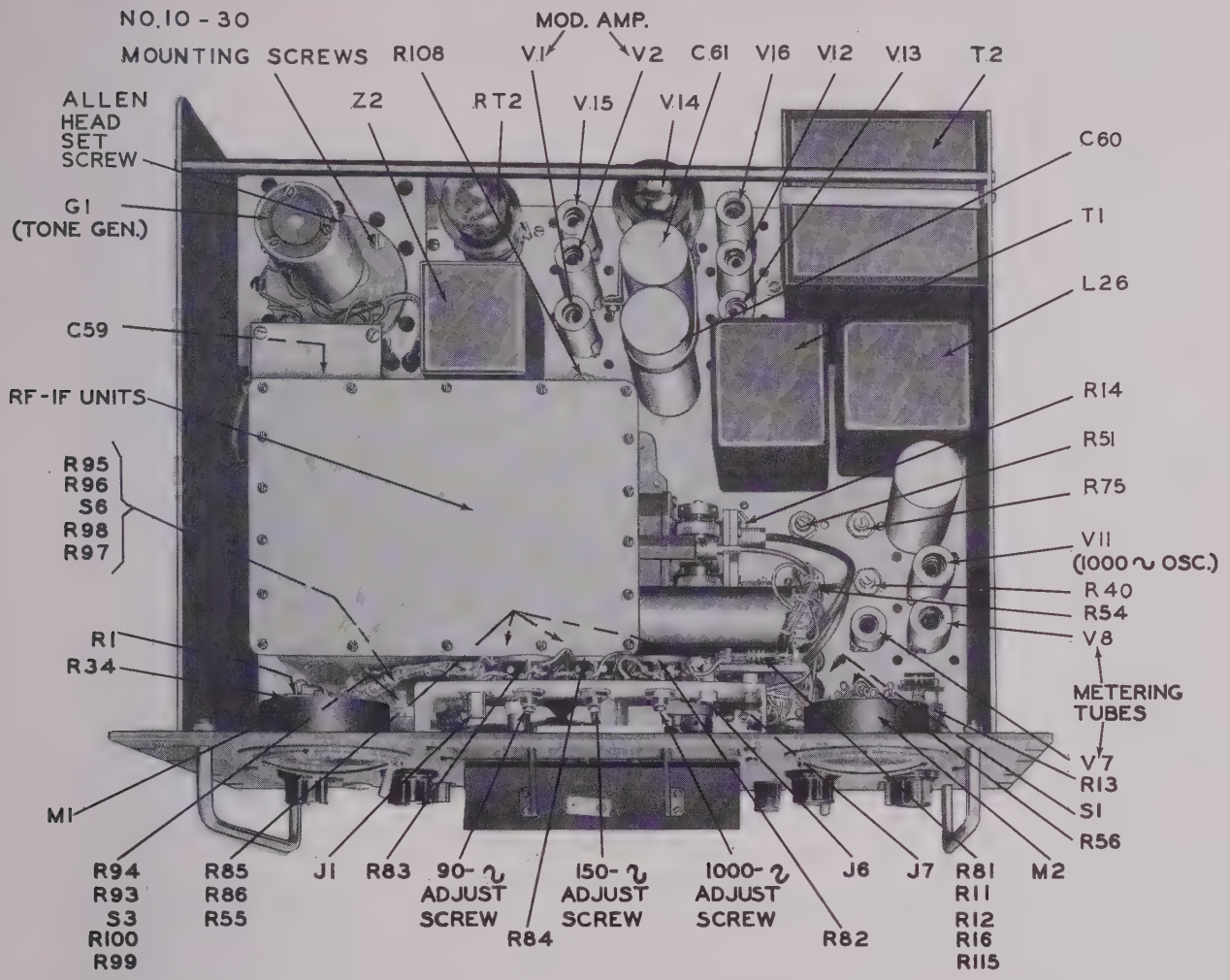


Figure 10. Top View of Chassis (Photo)

B. RF ALIGNMENT

Prior to rf alignment the generator should be operated, in the cabinet, for at least two hours to allow it to reach normal operating temperature. All shield plates should be in place and the CARRIER switch turned to RF during this warmup. During alignment, the bottom shield plate on the rf unit must be in place for it influences the alignment of the output tank circuits.

The equipment required for aligning the RF section is: (1) D.C. Voltmeter 0-50 V, 20,000 ohms per volt, or better, such as Simpson 260 or RCA Jr. Voltohmist. (2) A small screwdriver. (3) A small insulated screwdriver.

RF ALIGNMENT PROCEDURE*

Step No.	*Test Point*	*Normal Indication*	*Controls Set At*	*Operation*
RF-1	J2	—40 to —50V	*Frequency Dial* — 332.0 mc *Carrier Switch* — *RF* *Mod Switch* — *Off* *Carrier Adjust* Control for "red line" On *Carrier Monitor Meter* or approx. ¾ of full clockwise rotation.	Remove top cover plate of RF Unit and adjust tuning slug of L13 for highest reading on test meter.

RF ALIGNMENT PROCEDURE *(Continued)*

Step No.	*Test Point*	*Normal Indication*	*Controls Set At*	*Operation*
RF-2	J3	—16 to — 25V	Same as for RF-1 except *Frequency Dial* alternately at 329.3 & 335 mc.	Adjust tuning slugs of L14 and L15 for highest *equal* readings at the two frequencies.
RF-3	J4	—8 to —15V	Same as for RF-2	Adjust tuning slugs of L16 and L17 for highest *equal* readings at the two frequencies.
RF-4	*Carrier Monitor Meter* as indicator	—	Same as for RF-1 except *Frequency Dial* at 329.3 mc.	Adjust C32 for peak reading on *Carrier Monitor Meter.* (The notched lock-washer should be kept moderately tight, and may require holding to avoid loosening during alignment).
RF-5	*Carrier Monitor Meter* as indicator	—	Same as for RF-1 except *Frequency Dial* at 332.0 mc.	Using the insulated screwdriver, adjust C35 for peak reading.
RF-6	Repeat steps RF-2, RF-3, RF-4 and RF-5 to correct for interaction between adjustments.			
RF-7	*Carrier Monitor Meter* as indicator	—	Same as for RF-1 except *Frequency Dial* alternately at 329.3 and 335.0 mc.	If the meter reading is not equal at the two frequencies, readjust C35. It may also be necessary to slightly re-set C32 to produce the desired effect from C35. The desired end result is an equal (or nearly equal) output on all 20 channels, with sufficient output reserve to allow setting to the "red line" under all conditions of operation. Normally the output at 329.3 and 335 mc will be about 3% to 5% less *(Carrier Adjust* control set for "red line" at 332.0 mc.) than on the other frequencies.
RF-8	—	—	Same as for RF-1 except *Carrier Adjust* Control full clockwise	Temporarily replace the top shield plate of the RF Unit (2 holding screws are sufficient) and slide the Signal Generator in the cabinet. Allow to operate for at least one hour to restore normal operating temperatures.
RF-9	*Carrier Monitor Meter* as indicator	—	Same as for RF-1	Set the *Carrier Monitor Meter* to "red line". Check output at 329.3 and 335.0 mc. If unequal, remove top shield plate and reset C35 to make the reading at 335.0 equal to or slightly greater than that at 329.3 mc. Replace the top cover plate, tightening screws firmly to avoid RF "leakage".

*The RF Alignment procedure as detailed covers all of the alignment operations normally required to restore proper RF performance after tube replacements — assuming that no component or other failures have occurred.

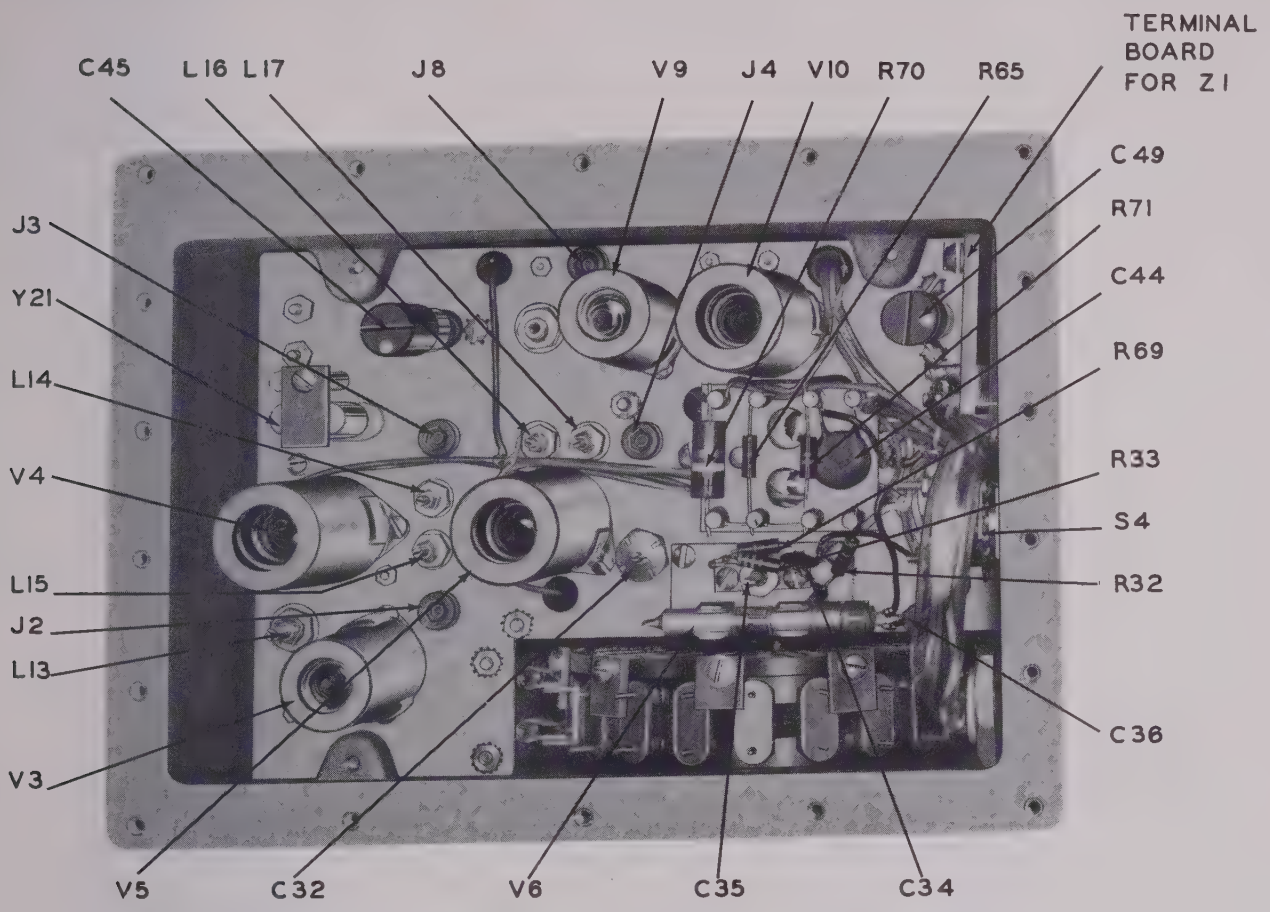


Figure 11. Top View of RF Subassembly with Cover Removed

C. I.F. ALIGNMENT

The IF system of the Generator has been designed to allow operation at any desired IF output frequency between 15 and 30 mc. As shipped, the IF is 20.7 mc. To shift to any other frequency, replace Y21 with a Type CR-18/U* crystal having a fundamental frequency one-quarter of the desired i-f output frequency and retune as described below.

The equipment required for aligning the IC section of the Generator is:

(a) A DC Voltmeter 0-50 V, 20,000 ohms per volt (or better) such as Simpson 260 or RCA Jr. Voltohmyst.

(b) A screwdriver.

IF ALIGNMENT PROCEDURE (see footnote and Fig. IV 2)

Step	*Test Point*	*Normal Indication*	*Controls Set At*	*Operation*
IF-1	J8	—15 to —25V	*Carrier* Switch on IF. *Carrier Adjust* set for "red line" on *Carrier Monitor Meter,* or set at ¾ of full rotation clockwise. *Mod* Switch to *Off.*	Remove the top cover plate of the RF Unit. Turn the slotted knob of C45 so that the dot points to the desired i-f output frequency as marked on the rf Chassis adjacent to the knob. Readjust for peak reading on the voltmeter.

IF ALIGNMENT PROCEDURE (see footnote and Fig. IV 2) *(continued)*

Step	*Test Point*	*Normal Indication*	*Controls Set At*	*Operation*
IF-2	*Carrier Monitor Meter* as indicator	—	Same as Step IF-1	Set the slotted knob of C49 so that the dot points to the desired IF output frequency as marked on the RF chassis adjacent to the knob. Carefully readjust for peak reading on the carrier monitor meter.
IF-3	*Carrier Monitor Meter* as indicator	—	Same as Step IF-1	See that the *Carrier Monitor Meter* can be set to "red line" using the *Carrier Adjust* control. If necessary, reset the control marked R14 IF *Set* to allow this.

*CR-18/U Crystal-parallel resonant at the fundamental mode. Frequency accuracy, ±.005% from −55 to +90°C when working into a 32±0.5μμf load capacitance.

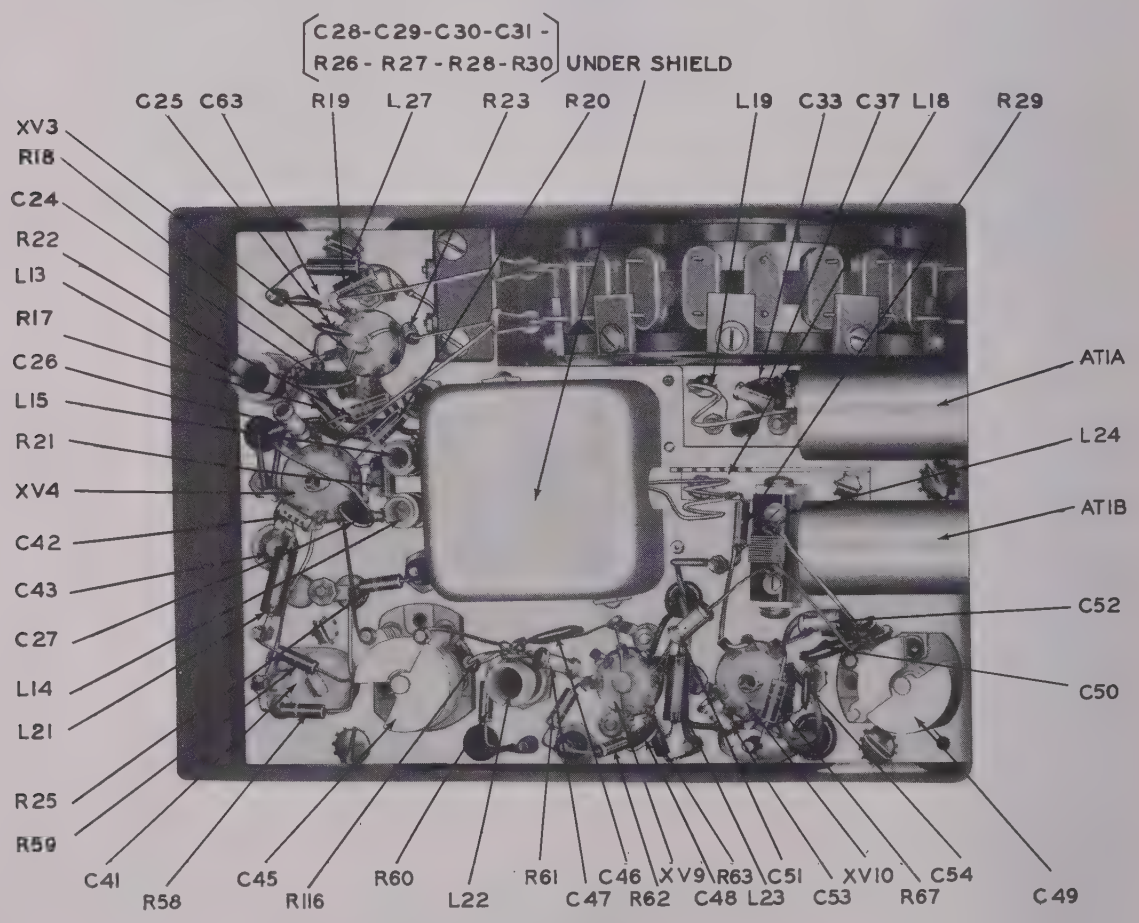


Figure 12. Bottom View of RF Subassembly with Cover Removed

D. ADJUSTMENT OF 1000 OSCILLATOR ~

The negative feedback control marked R75 1000 ~ *Cal.* should be set to produce an output voltage of approximately 13V RMS as measured at the end of R81 (68K 1W Resistor on back of panel terminal board, nearest the *Carrier Monitor Meter).*

E. POWER SUPPLY ADJUSTMENT

Potentiometer R108 marked "+260V ADJ" should be set to produce 260V ±10V at pin 3 or 6 of tube V14 (6AS7G). Normally, this control need be adjusted only if tubes V15 or V16 (6AU6 and OB2) are replaced. If the OB2 has been replaced, it is desirable to "age in" the tube for two or three hours of operation before adjusting R108.

F. METER RECALIBRATION

General

The *Carrier Monitor Meter* is essentially a dc voltmeter, used to read the rise of dc voltage at the cathode of the follower caused by rectified carrier. The *Percent Modulation Meter* functions as an ac vacuum tube voltmeter reading the audio component of the carrier.

The calibration of both meters may be checked by connecting calibrated "standard" meters to the *Meter Calib* tip jacks.

Standard Meters required are as follows:

(a) D.C. Voltmeter 0-50V, 100,000 ohms or more. Calibrated to be accurate within ½% from 20 to 50V.

(b) A.C. Voltmeter 0-10V, impedance greater than 100,000 ohms. Calibrated to be accurate within 2% at 6.68 and 7.92V RMS at 90 cycles.

Calibration of the "Carrier Monitor" Meter

Connect the calibrated D.C. Voltmeter to the *Meter Calib* tip jacks (J6 and J7); turn the *Carrier* Switch (S1) to *Off;* and carefully zero the *Carrier Monitor* meter (M2), using its *Zero* control (R56). Read the D.C. meter (normal reading is approximately 27 volts).

Switch to RF, and set the *Carrier Adjust* control (R13) for a reading on the D.C. voltmeter exactly 22 V. higher than that obtained in the preceding step.

Check the reading of the *Carrier Monitor* meter, which should read red line. If it does not, adjust the *Mon Cal* control (R54) to produce a red line reading.

Repeat the procedure to insure greatest accuracy.

Calibration of the "Percent Modulation" Meter

Connect the calibrated A.C. voltmeter to the *Meter Calib.* tip jacks. Turn the *Mod* switch (S5) to 90-150 ~; the *DB Tne Ratio* switch (S6), to *Cal* 90 ~; the modulation range switch (S3) to 0-50%, and set the *Carrier Monitor* meter to the red line.

Adjust the *Mod Level* control (R1) for a reading of exactly 6.68 volts on the AC voltmeter. The *Percent Modulation* meter should now read 42%. If necessary, adjust the 50% *Cal* control (R40) to produce a reading of 42%.

Operate the meter range switch to the 0-100% range, adjust the *Mod Level* control for a reading of exactly 7.92 volts on the AC voltmeter and, if necessary, adjust the 100% *Cal* control (R51) for a reading of exactly 50% on the *Percent Modulation meter.*

*NOTE: The 0-50% range must be calibrated before the 0-100% range.

Set-up of Mod Level Control Knob

Turn the *Carrier* switch (S1) to RF, the *Mod Level* control (R1) full counterclockwise, the *Frequency* dial to 332.0 mc, the *Mod* switch (S5) to the 90-150 ~ position, the *DB Tone Ratio* switch (S6) to *Cal* 90 ~, and set the *Carrier Monitor* meter (M2) to the red line using the *Carrier Adjust* control (R13). Turn the 90~ (R83), 150~ R84 and 1000 ~ (R82) controls (located behind the panel door) full clockwise.

Advance the *Mod Level* control until the *Percent Modulation* meter reads 46% (with the meter range switch (S3) in the 0-100% position). Switch to *Cal* 150 ~ and note the reading of the *Percent* Modulation meter. If it is more than 46%, reduce to 46%; if it is less than 42%, increase to 42% using the *Mod Level* control. The pointer of the *Mod Level* control knob should be at the reference mark (vertical). If it is not, loosen its set screws and reposition it to be so. Tighten set screws and check to be sure the electrical setting of the *Mod Level* control has not been disturbed.

With the *DB Tone Ratio* switch at the *Cal* 90~ position, set the 90~ control for a reading of exactly 40% on the *Percent Modulation* meter. Switch to *Cal* 150~ and similarly set the 150~ control for a reading of exactly 40%. Switch from the *Cal* 90~to the *Cal* 150~ position several times to be sure that the *Percent Modulation* meter reads 40% on each.

With the *DB Tone Ratio* switch in either the *Cal* 90~ or the *Cal* 150~ position, turn the *Mod Level* control fully clockwise. The *Percent Modulation* meter should read more than 100%.

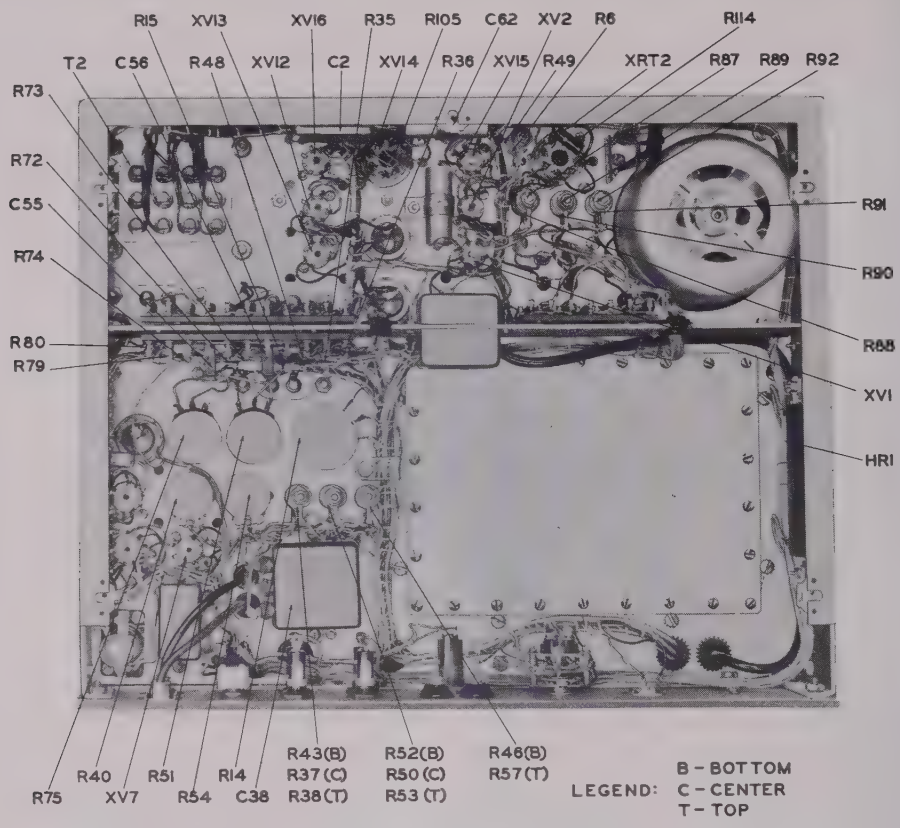


Figure 13. Bottom View of Chassis — Partial call-outs

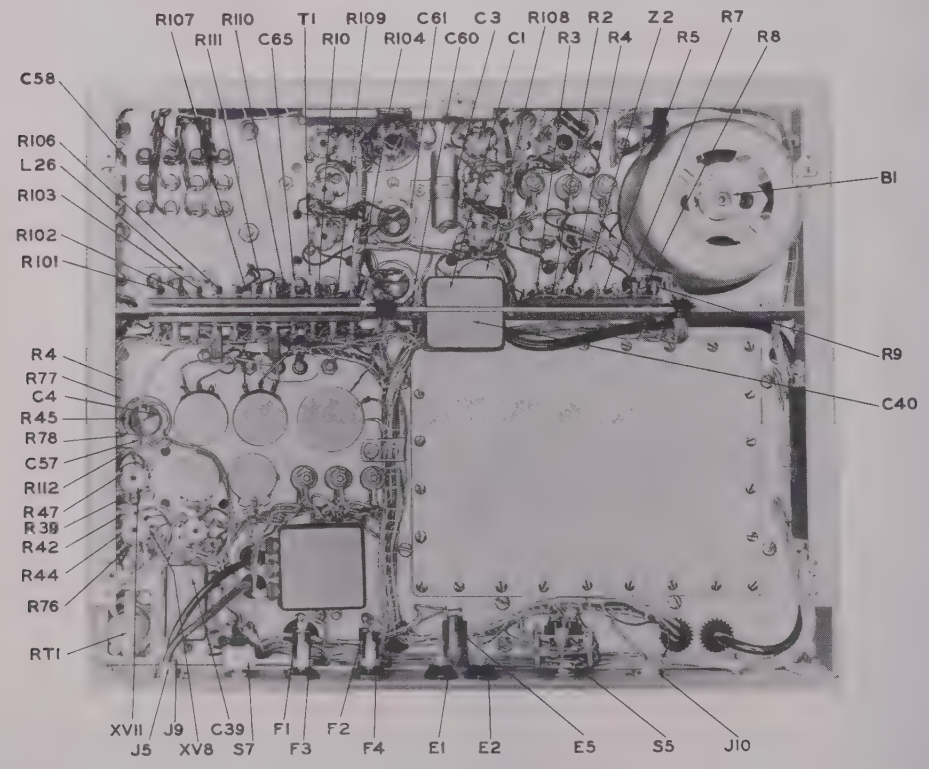


Figure 13a Bottom View of Chassis — Remainder of call-outs

SECTION V
TROUBLE SHOOTING

GENERAL PROCEDURE

The usual procedure of localizing trouble within one of the circuits, then determining the component at fault, is recommended in servicing this Generator. Frequently, visual inspection alone will serve to locate trouble. A Glide Slope receiver may be used to detect the existence of rf output and modulation if meter circuits are not functioning.

The following chart is offered as a troubleshooting guide, and while not all-inclusive, suggests a testing sequence that should prove helpful. In the chart, testing is grouped under logical circuit headings. It should be borne in mind, however, that it is not always possible to treat each circuit group independently and that in some cases there is interdependence between circuit groups for proper overall functioning.

TEST EQUIPMENT REQUIRED

(a) DC Voltmeter — 20,000 /volt — or better (Simpson 260, Jr. Volt-Ohmyst, etc.).

(b) AC Voltmeter — 500,000 impedance shunted with 30$\mu\mu$f—or better (Ballantine 300, etc.).

TROUBLESHOOTING CHART

(See photo illustrations for location of test points)
(All tests between test point specified and chassis)

POWER SUPPLY

STEP NO.	TEST POINT	CONTROLS SET AT	NORMAL INDICATION	PROBABLE CAUSE OF MALFUNCTIONING
1	Pin 7 of V12 or V13 (546-As)	*Power* switch (S7) *On*	+360V D.C. (approx.) with 115V line input. (Varies with line input voltage).	V12 or V13 (546-As)
2	Pin 2 or Pin 5 of V14 (6AS7G)	Same as Step (1)	+260V DC. The normal adjustment range of R108 is from approx. 200 to 320V DC. With B+ set to 260V using R108, removal of V2 *(Caution — This tube gets HOT in normal operation)* (6005/6AQ5W) should cause less than 1 volt change of readings on the voltmeter.	Malfunctioning may be caused by either excessive drain, improper regulaton, or both. Improper regulation only at low line input voltage is usually due to a weak 6AS7G (V14). Improper or no regulation at all line inputs is probably due to a weak or burned out 6AU6 (V15).
3	Pin 2 of RT2 (16-4)	Same as Step (1)	7V A.C. ±.3V.	If voltage 10% or more high— Burned out tube or tubes in RF unit (V3, 4, 5, 6, 9 or 10). If below 6.7V, RT2 at end of useful life. Badly deformed filament of RT2 also indcates approach of end of useful life.
			1000〜OSCILLATOR	
4	End of R81 (68K 1W on sub-panel terminal board) nearest *Carrier Monitor Meter*	*Power* switch (S7) *On* *Mod* switch (S5) set at 1000	Approx. 13V A.C. (The normal adjustment range of R75 "1000〜 *Cal*" is from 0 to 25 volts AC)	If adjustment range abnormal, RT1
			90/150〜GENERATOR	
5	90〜 terminal on alternator TB	*Power* switch (S7) *On.* *Mod* switch (S5) at 90/150〜 *DB Tone Ratio* switch (S6) at *Cal 90〜*	6-8V AC	90〜 section of alternator G1
6	150〜 terminal on alternator TB	Same as Step (5)	6-8V AC	150〜 section of alternator G1

TROUBLESHOOTING CHART (Continued)

STEP NO.	TEST POINT	CONTROLS SET AT	NORMAL INDICATION	PROBABLE CAUSE OF MALFUNCTIONING
7	Term. #3 of the 90/150~ filter Z2	Same as Step (5) 90~ control (R83) turned full clockwise	7-10V AC	90~ section of filter Z2 or R83 or R85
8	Term. #6 of the 90/150~ filter Z2	Same as step (5) 150~ control (R84) turned full clockwise	7-10V AC	150~ section of filter Z2 or R84 or R-86
9	Pin #1 of V1 (6AU6)	*Power* switch (S7) *On*. *Carrier* (S1) switch on RF or IF. *Carrier Monitor* (M2) meter set to "red line" with *Carrier Adjust* control (R13). *Mod* switch at 90/150~ . 90~ (R83) control and 150~ (R84) controls set for a reading of exactly 40% on the *Percent Modulation* (M1) meter with the *DB Tone Ratio* switch set at the *Cal 90* and *Cal 150* positions respectively.	On *Cal 90~* OR *Cal 150~* positions of *DB Tone Rato* switch (S6) and varying setting of *Mod Level* control (R1): 0 — approx. 1.2V AC.	Defective resistor, R87 thru R100
		MODULATION AMPLIFIER		
10	*Modulator Output* jack, J1	*Power* switch (S7) *On*. *Carrier* switch (S1) *Off*. *Mod* switch (S5) at *Ext. Mod Level* control (R1) fully clockwise. 1v of 400 cps audio fed into the *Ext Mod* input jack (J10)	10-12V AC	V1 or V2
		CARRIER MONITOR METER CIRCUITS		
11A	Yellow *Meter Calib* jack J6	*Power* switch *Off*	8000 to 9000 ohms	If either low or high suspect R49 or R6
11B	J6	*Power* switch (S7) *On*. *Carrier* switch (S1) *Off*.	26-30V DC	V10
12	J6. Negative terminal of *Carrier Monitor* meter M2	*Power* switch (S7) *On*. *Carrier* switch (S1) *Off*. *Carrier Monitor* meter (M2) *Zero* control (R56) varied over its full control range.	Approx. range 20 to 35V DC	R55, 56, 57 or V16 (0B2)
		RF AND IF GENERATOR CIRCUITS		

The alignment procedures for the RF and IF Generators detailed in section IV will also serve for troubleshooting these circuits.

Voltage and Resistance Charts:

Tables of the nominal socket voltage and resistances are included to assist in locating trouble. For these measurements the *Carrier* switch was in the RF position and the *Mod* switch on *Off* except as otherwise noted.

RESISTANCE CHART

Symbol		Pin Number								
		1	2	3	4	5	6	7	8	9
V1	6AU6	1M	435	Fil.	Fil.	.5M	1.5M	435	—	—
V2	6AQ5W/6005	.47M	330	Fil.	Fil.	23K	23K	330	—	—
V3	6AU6	0	0	Fil.	0	23K	70K	330	—	—
V4	12AT7	23K	93K	330	0	0	∞	.1M	1K	Fil.
V5	538-B	26.5	20K	0	0	0	42K	9.4K	0	Fil.
V6	6173	10K*	340K**	—	—	—	—	—	—	—
V7	5726	0	710	Fil.	Fil.	∞	NC	∞	—	—
V8	12AT7	56K	1M	680	Fil.	Fil.	.49M	1M	22K	Fil.
V9	6AU6	94K	0	0	Fil.	22K	22K	0	—	—
V10	538-B	10K	10K	.34M	Fil.	Fil.	23K	.4M	9K	0
V11	12AT7	123K	150K	1.25K	Fil.	Fil.	38K	.47M	330	Fil.
V12	546-A	52	NC	.24M	.24M	NC	52	.24M	—	—
V13	546-A	47	NC	.24M	.24M	NC	47	.24M	—	—
V14	6AS7G	1.4M	.24M	23K	1.4M	.24M	23K	20K	20K	—
V15	6AU6	.13M	20K	20K	20K	1.4M	78K	20K	—	—
V16	OB2	21K	0	NC	0	21K	NC	0	—	—
RT2	Ballast	NC	.4	NC	NC	NC	23K	Fil.	NC	—

NOTES: *Plate (adjacent to pinch off)
**Cathode (adjacent to filaments)
NC No Connection
RF Off IF switch in RF position
K=1000 ohms
M=1,000,000 ohms

SOCKET VOLTAGES

Symbol		Pin Number								
		1	2	3	4	5	6	7	8	9
V1	6AU6	.05	2.8	0	6.3 AC	90	53.2	2.8	—	—
V2	6AQ5W/6005	0	13.8	0	6.3 AC	231	260	0	—	—
V3	6AU6	0	0	6.3 AC	0	257	114.8	2.6	—	—
V4	12AT7	255	J2—38	2.9	0	0	256.2*	—8.96*	** 6.3*	6.3 AC
V5	538-B	186	J3—21.50	0	0	0	110	J4—9.30	0	6.3 AC
V6	6173	20.5** †	39** ††	—	—	—	—	—	—	—
V7	5726	0	0	6.3 AC	0	.29	NC	—.25	—	—
V8	12AT7	150	0	2.1	6.3 AC	6.3 AC	125	0	5.5	0
V9	6AU6	J8—19.20*	0	0	6.3 AC*	101.8*	102.8*	0	—	—
V10	538-B	22.3	22.3	23	6.3 AC	6.3 AC	260	44	49.5	0
V11	12AT7	114	0	1.6	6.3 AC	6.3 AC	175	0	1.68	0
V12	546-A	430 AC	NC	360	360	NC	430 AC	360	—	—
V13	546-A	430 AC	NC	360	360	NC	430 AC	360	—	—
V14	6AS7G	225	350	260	225	350	260	108	108	—
V15	6AU6	100	108	108	108	225	225	108	—	—
V16	OB2	108	0	NC	NC	108	NC	0	—	—
RT2	Ballast	NC	7 AC	NC	NC	NC	260	14 AC	NC	—

NOTES:
*Carrier switch in IF position.
**100 K ohm in series with meter lead.
†Plate
††Cathode
20 K ohm/volt dc voltmeter.

SECTION VI

APPENDIX

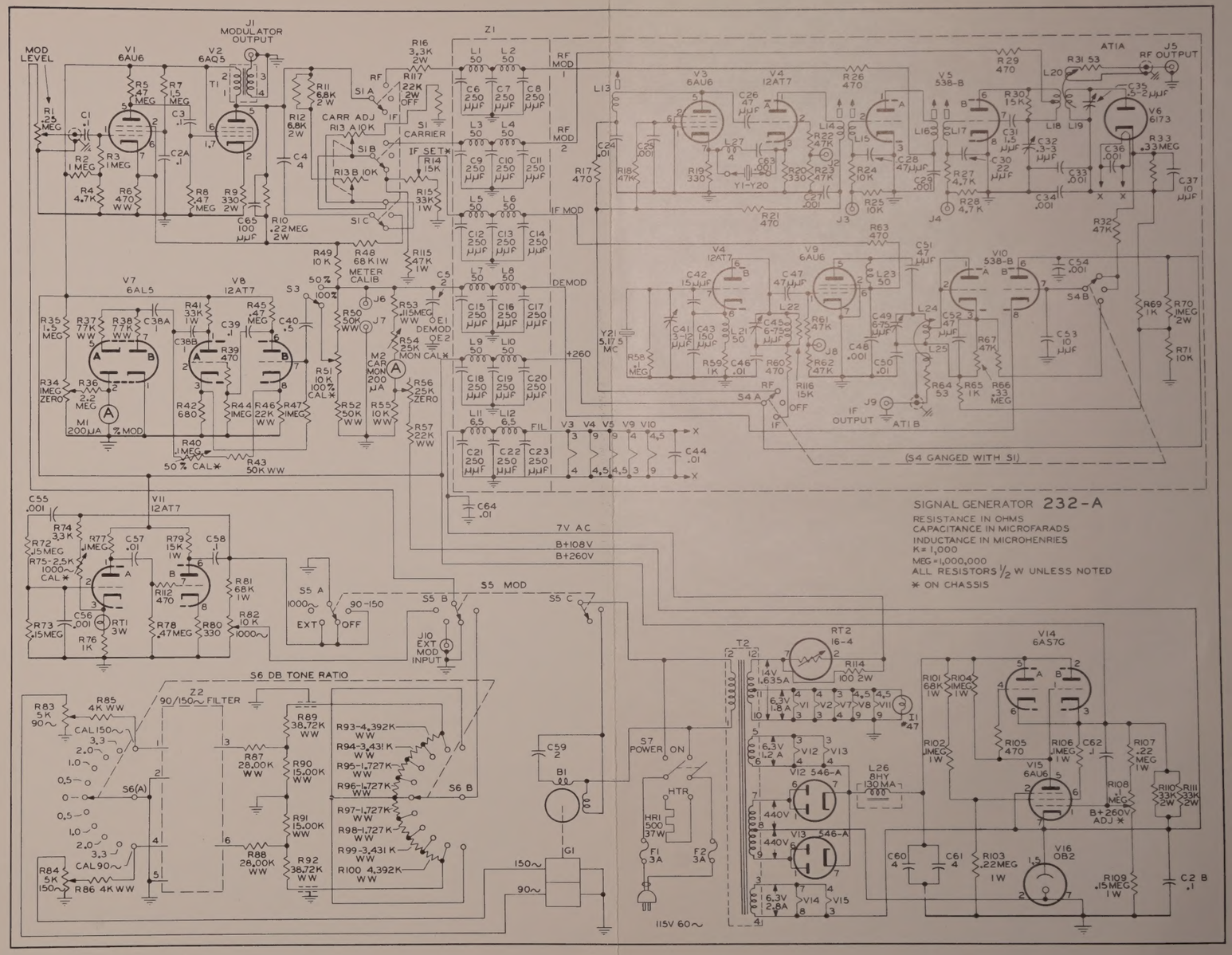
ELECTRICAL COMPONENTS

Circuit Symbol	Value	Description	BRC Part No.
R-1	.25M Ω	Resistor, Variable ±10% 2W	A81602
R-2	1M Ω	Resistor, Fixed ± 5% 1/2W	A80621
R-3	1M Ω	Resistor, Fixed ± 5% 1/2 W	A80621
R-4	4.7K Ω	Resistor, Fixed ± 5% 1/2W	80304
R-5	.47M Ω	Resistor, Fixed ±5% 1/2W	80640
R-6	470 Ω	Resistor FIXED WW ±1% 1/4W	A80152-5
R-7	1.5M Ω	Resistor Fixed ± 5% 1/2W	80643
R-8	.47M Ω	Resistor, Fixed ±5% 1/2W	80640
R-9	330 Ω	Resistor, Fixed ± 5% 2W	B80038-14
R-10	.22M Ω	Resistor, Fixed ±5% 2W	B80038-18
R-11	6.8K Ω	Resistor, Fixed ±5% 2W	B80038-19
R-12	6.8K Ω	Resistor, Fixed ±5% 2W	B80038-19
R-13	10K Ω	Resistor, Variable ±10% 2W	A81020-5
R-14	15K Ω	Resistor, Variable ±10% 4W	A81020-4
R-15	33K Ω	Resistor, Fixed ± 5% 1W	80488
R-16	3.3K Ω	Resistor, Fixed ±5% 2W	B80038-15
R-17	470 Ω	Comm-Resistor, Fixed ±5% 1/2W	A80170
R-18	47K Ω	Resistor, Fixed, ±5% 1/2W	A80460
R-19	330 Ω	Resistor, Fixed ±5% 1/2W	A80172
R-20	330 Ω	Resistor, Fixed ±5% 1/2W	A80172
R-21	470 Ω	Comm-Resistor, Fixed ±5% 1/2W	A80170
R-22	47K Ω	Resistor Fixed ±5% 1/2W	A80460
R-23	47K Ω	Resistor, Fixed ±5% 1/2W	A80460
R-24	10K Ω	Resistor, Fixed ±5% 1/2W	A80361
R-25	10K Ω	Resistor, Fixed ±5% 1/2W	A80361
R-26	470 Ω	Resistor, Fixed ±5% 1/2W	A80170
R-27	4.7K Ω	Resistor, Fixed ±5% 1/2W	80304
R-28	4.7K Ω	Resistor, Fixed ±5% 1/2W	80304
R-29	470 Ω	Resistor, Fixed ±5% 1/2W	A80170
R-30	15K Ω	Resistor, Fixed ±5% 1/2W	80392
R-31	53 Ω	Resistor, Fixed ±2% (Grd from A80088)	A80712
R-32	47K Ω	Resistor, Fixed ±5% 1/2W	A80460
R-33	.33M Ω	Resistor, Fixed ±5% 1/2W	80651
R-34	1M Ω	Resistor, Var. ±10% 2W	A81021-5
R-35	1.5M Ω	Resistor , Fixed ±5% 1/2W	80643
R-36	2.2M Ω	Resistor, Fixed ±5% 1/2W	80649
R-37	77K Ω	Resistor, Fixed WW ±1% 1/2W	A80152-2
R-38	77K Ω	Resistor, Fixed WW ±1% 1/4W	A80152-2
R-39	470 Ω	Resistor, Fixed ±5% 1/2W	A80170
R-40	.1M Ω	Resistor, Var. ±10% 2W	A81021-3
R-41	33K Ω	Resistor, Fixed ±5% 1W	80488
R-42	680 Ω	Resistor, Fixed ±5% 1/2W	80138
R-43	50K Ω	Resistor, Fixed WW ±1/2% 1/4W	A80152-1
R-44	1M	Resistor, Fixed ±5% 1/2W	A80621
R-45	.47M	Resistor, Fixed ±5% 1/2W	80640
R-46	22K Ω	Resistor, Fixed WW ±1% 1/4W	A80152-3
R-47	1M	Resistor, Fixed ±5% 1/2W	A80621
R-48	68K Ω	Resistor, Fixed ±5% 1W	A80552
R-49	10K Ω	Resistor, Fixed WW ±1% 1/4W	A80152-6
R-50	50K Ω	Resistor, Fixed WW ± 1/2% 1/4W	A80152-1
R-51	10K Ω	Resistor, Variable ±10% 2W	A81020-3
R-52	50K Ω	Resistor, Fixed WW ± 1/2% 1/4W	A80152-1
R-53	.115M Ω	Resistor, Fixed WW ± 1% 1/4W	A80152-4
R-54	25K Ω	Resistor, Variable ±10% 2W	A81021-1
R-55	10K Ω	Resistor, Fixed WW ±1% 1/4W	A80152-6
R-56	25K Ω	Resistor, Variable ±10% 2W	A81021-1
R-57	22K Ω	Resistor, Fixed WW ±1% 1/4W	A80152-3
R-58	.1M Ω	Resistor, Fixed ±5% 1/2W	A80517
R-59	1K Ω	Resistor, Fixed ±5% 1/2W	A80148

Circuit Symbol	Value	Description	BRC Part No.
R-60	470 Ω	Comm-Resistor, Fixed ±5% 1/2W	A80170
R-61	47K Ω	Resistor, Fixed ±5% 1/2W	A80460
R-62	47K Ω	Resistor, Fixed ±5% 1/2W	A80460
R-63	470 Ω	Comm-Resistor, Fixed ±5% 1/2W	A80170
R-64	53 Ω	Resistor, Fixed ±2% (Grd from A80088)	A80712
R-65	1K Ω	Resistor, Fixed ±5% 1/2W	A80148
R-66	.33M Ω	Resistor, Fixed ±5% 1/2W	80651
R-67	47K Ω	Resistor, Fixed ±5% 1/2W	A80460
R-69	1K Ω	Resistor, Fixed ±5% 1/2W	A80148
R-70	.1M Ω	Resistor, Fixed ±5% 2W	B80038-17
R-71	10K Ω	Resistor, Fixed ±5% 1/2W	A80361
R-72	.15M Ω	Resistor , Fixed ±5% 1/2W	80564
R-73	.15M	Resistor, Fixed ±5% 1/2W	80564
R-74	3.3K Ω	Resistor, Fixed ±5% 1/2W	A80253
R-75	2.5K Ω	Resistor, Var. ±10% 2W	A81020-1
R-76	1K Ω	Resistor, Fixed ±5% 1/2W	A80148
R-77	.1M Ω	Resistor, Fixed ±5% 1/2W	A80517
R-78	.47M Ω	Resistor, Fixed ±5% 1/2W	80640
R-79	15K Ω	Resistor, Fixed ±5% 1W	80337
R-80	330 Ω	Resistor, Fixed ±5% 1/2W	A80172
R-81	68K Ω	Resistor, Fixed ±5% 1W	A80552
R-82	10K Ω	Resistor, Var. ±10% 2W	A81020-3
R-83	5K Ω	Resistor, Var. ±10% 2W	A81020-2
R-84	5K Ω	Resistor, Var ±10% 2W	A81020-2
R-85	4K Ω	Resistor, Fixed ±1% 1/4W	A80152-7
R-86	4K Ω	Resistor, Fixed ±1% 1/4W	A80152-7
R-87	28K Ω	Resistor, Fixed ±1/2% 1/4W	A80152-8
R-88	28K Ω	Resistor, Fixed ±1/2% 1/4W	A80152-8
R-89	38.72K Ω	Resistor, Fixed ±1/4% 1/4W	A80152-10
R-90	15K Ω	Resistor, Fixed ±1/2% 1/4W	A80152-9
R-91	15K Ω	Resistor, Fixed ±1/2% 1/4W	A80152-9
R-92	38.72K Ω	Resistor, Fixed ±1/4% 1/4W	A80152-10
R-93	4.392K Ω	Resistor, Fixed ±1/4% 1/4W	A80152-11
R-94	3.431K Ω	Resistor, Fixed ±1/4% 1/4W	A80152-12
R-95	1.727K Ω	Resistor, Fixed ±1/4% 1/4W	A80152-13
R-96	1.727K Ω	Resistor, Fixed ±1/4% 1/4W	A80152-13
R-97	1.727K Ω	Resistor, Fixed ±1/4% 1/4W	A80152-13
R-98	1.727K Ω	Resistor, WW ±1/4% 1/4W	A80152-13
R-99	3.431K Ω	Resistor WW ±1/4% 1/4W	A80152-12
R-100	4.392K Ω	Resistor, WW ± 1/4% 1/4W	A80152-11
R-101	68K Ω	Resistor, Fixed ±5% 1W	A80552
R-102	.1MΩ	Resistor, Fixed ±5% 1W	A80521
R-103	.22MΩ	Resistor, Fixed ±5% 1W	80553
R-104	1M Ω	Resistor, Fixed ±5% 1W	A80625
R-105	470 Ω	Resistor, Fixed ±5% 1/2W	A80170
R-106	.1M Ω	Resistor, Fixed ±5% 1W	A80521
R-107	.22M Ω	Resistor, Fixed ±5% 1W	80553
R-108	.1M Ω	Resistor, Var. ±10% 2W	A81021-3
R-109	.15M Ω	Resistor, Fixed ±5% 1W	A80528
R-110	33K Ω	Resistor, Fixed ±5% 2W	B80038-13
R-111	33K Ω	Resistor, Fixed ±5% 2W	
R-112	470 Ω	Resistor, Fixed ±5% 1/2W	A80170
R-114	100	Resistor, Fixed ±5% 2W	B80038-7
R-115	47K Ω	Resistor, Fixed ±5% 1W	80470
R-116	15K Ω	Resistor, Fixed ±5% 1/2W	A80336
R-117	22K Ω	Resistor, Fixed ±5% 2W	B80038-20
C-1	.1μf	Cap. Fixed +20%-10% 600V	83063
C-2	.1 - .1μf	Cap. Fixed +20-10% 600V	B83026-3
C-3	.1μf	Cap. Fixed ±20% 600V	B83087-6
C-4	4μf	Cap. Fixed +20%-10% 600V	83069
C-5	2.0μf	Cap. Fixed +20%-10% 200V	B83026-4
C-6thru C-23	250μμf	Cap. Fixed ±10% 500V	82232
C-24	.01μf	Cap. Fixed +80%-20% 600V	82428
C-25	.001μμf	Cap. Fixed +80%-20% 600V	82306

Circuit Symbol	Value	Description	BRC Part No.
C-26	47μμf	Cap. Fixed ±5%	82109
C-27	.001μμf	Cap. Fixed +80-20% 600V	82306
C-28	47μμf	Cap. Fixed ±5%	82109
C-29	.001μμf	Cap. Fixed +80-20% 600V	82306
C-30	22μμf	Cap. Fixed ±5%	B83000-9
C-31	1.5μμf	Cap. Fixed	82148
C-32	.3-3μμf	Cap. Var.	84000
C-33	.001μμf	Cap. Fixed +80-20% 600V	82306
C-34	.001μμf	Cap. Fixed +80-20% 600V	82306
C-35	.5-2μμf	Cap. Var.	84081
C-36	.001μμf	Cap. Fixed +80-20% 600V	82306
C-37	10μμf	Cap. Fixed	B83000-7
C-38	1.-1.μf	Cap. Fixed +20-10% 600V	B83026-5
C-39	.1μf	Cap. Fixed +20-10% 600V	83063
C-40	.5μf	Cap. Fixed +20-10% 600V	83073
C-41	3-12μμf	Cap. Var.	84014
C-42	15μμf	Cap. Fixed ±2%	B83000-8
C-43	150μμf	Cap. Fixed ±5%	82201
C-44	.01μf	Cap. Fixed +80-20% 600V	82428
C-45	6-75μμf	Cap. Var.	A84080
C-46	.01μf	Cap. Fixed +80-20% 600V	82428
C-47	47μμf	Cap. Fixed ±5%	82109
C-48	.001μμf	Cap. Fixed +80-20% 600V	82306
C-49	6-75μμf	Cap. Var.	A84080
C-50	.01μf	Cap. Fixed +80-20% 600V	82428
C-51	47μμf	Cap. Fixed ±5%	82109
C-52	47μμf	Cap. Fixed ±5%	82109
C-53	10μμf	Cap. Fixed ±5%	B83000-7
C-54	.001μμf	Cap. Fixed +80%-20% 600V	82306
C-55	.001μμf	Cap. Fixed ±2% 500V	B83005-1
C-56	.001μμf	Cap. Fixed ±2% 500V	B83005-10
C-57	.01μμf	Cap. Fixed +80%-20% 600V	B83005-10
C-58	.5μf	Cap. Fixed +20%-10% 600V	83063
C-59	2μf	Cap. Fixed ±5%	A83085
C-60	4μf	Cap. Fixed ±20%-10% 600V	83069
C-61	4μf	Cap. Fixed +20%-10% 600V	83069
C-62	.1μf	Cap. Fixed ±20% 600V	B83087-6
C-63	.001μμf	Cap. Fixed +80%-20% 600V	82306
C-64	.01 μf	Cap. Fixed +80% -20% 600V	82428
C-65	100μμf	Cap. Fixed ±5%	B83005-5
L-1 thru L-10	50μh	Coil, Radio Frequency	A85592
L-11	6.5μh	Coil, Radio Freq. ±5%	A85599
L-12	6.5μh	Coil, Radio Freq. ±5%	A85599
L-13		Coil, Radio Frequency	A302238
L-14		Coil, Radio Frequency	A302239
L-15		Coil, Radio Frequency	A302239
L-16		Coil, Radio Frequency	A302240
L-17		Coil, Radio Frequency	A302240
L-18		Coil, Radio Frequency	A302243
L-19		Coil, Radio Frequency	A302244
L-20		Attenuator Pick Up Loop	
L-26	8hy-130ma	Reactor	B302631
L-27	4μh	Coil, Radio Freq.	A85600
V-1		Tube	6AU6
V-2		Tube	6005/6AQ5W
V-3		Tube	6AU6
V-4		Tube	12AT7
V-5		Tube (selected 12AT7)	538-B
V-6		Tube	91307
V-7		Tube	5726/6AL5W
V-8		Tube	12AT7
V-9		Tube	6AU6
V-10		Tube (selected 12AT7)	538-B

Circuit Symbol	Value	Description	BRC Part No.
V-11		Tube	12AT7
V-12		Tube (selected 6X4W)	546-A
V-13		Tube (selected 6X4W)	546-A
V-14		Tube	6AS7G
V-15		Tube	6AU6
V-16		Tube	OB2
I-1	No. 4	Light Indicator	A89023
RT-1		Lamp	A90907
RT-2	Ballast	Resistor, Thermal	16-4
S-1	3P-3Pos.	Switch, Rotary	A301973
S-3	Toggle	Switch, Toggle	A88040
S-4	2P-3Pos.	Switch, Rotary	A301966
S-5	2P-4Pos.	Switch, Rotary	A301977
S-6	2P-11Pos.	Switch, Rotary	A301975
S-7	Toggle	Switch, Toggle	A88055
J-1		Connector, Receptacle UG-290/U	302353
J-2		Connector, Tip Jack	301970
J-3		Connector, Tip Jack	301970
J-4		Connector, Tip Jack	301970
J-5		Connector, Receptacle UG-291/U	A89065
J-6		Connector, Receptacle	302227
J-7		Connector, Receptacle	302227
J-8		Connector, Tip Jack	301970
J-9		Connector, Receptacle UG-291/U	A89065
J-10		Connector, Receptacle UG-290/U	302353
J-11		Con	
Y-1	27.44014MC	Crystal Unit	A302643-1
Y-2	27.46519MC	Crystal Unit	A302643-2
Y-3	27.49023MC	Crystal Unit	A302643-3
Y-4	27.51528MC	Crystal Unit	A302643-4
Y-5	27.54034MC	Crystal Unit	A302643-5
Y-6	27.56540MC	Crystal Unit	A302643-6
Y-7	27.59047MC	Crystal Unit	A302643-7
Y-8	27.61553MC	Crystal Unit	A302643-8
Y-9	27.64061MC	Crystal Unit	A302643-9
Y-10	27.66568MC	Crystal Unit	A302643-10
Y-11	27.69076MC	Crystal Unit	A302643-11
Y-12	27.71585MC	Crystal Unit	A302643-12
Y-13	27.74094MC	Crystal Unit	A302643-13
Y-14	27.76607MC	Crystal Unit	A302643-14
Y-15	27.79119MC	Crystal Unit	A302643-15
Y-16	27.81632MC	Crystal Unit	A302643-16
Y-17	27.84144MC	Crystal Unit	A302643-17
Y-18	27.86657MC	Crystal Unit	A302643-18
Y-19	27.89169MC	Crystal Unit	A302643-19
Y-20	27.91682MC	Crystal Unit	A302643-20
Y-21	5.175KC	Crystal Unit	A302642-4
AT1		Attenuator Assembly	D302664
B-1		Motor, AC	B302637
G-1		Generator, AC	A302638
M-1		Meter, Modulation	A302635
M-2		Meter, Arbitrary Scale	A302634
F-1		Fuse Cartridge	95032
F-2		Fuse Cartridge	95032
E-1		Post, Binding	300538
E-2		Post, Binding	300538
HR1	500 Ω	Resistor, Fixed WW ±5% 37W	B80039-6



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